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## A REVIEW OF THE ARTICLES ON TUBERCULOSIS IN THE FIELD OF OTOLARYNGOLOGY CHIEFLY FOR LATE 1940 AND EARLY 1941.

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The European conflict has made a noticeable difference in the number and quality of the articles appearing from Europe. This was expected, but in spite of the war some excellent articles have been published.

There is much repetition in many of the articles which is always apparent to the reviewer. However, progress is being made. For instance, the discussion, which has been in the foreground for the past 10 years, about hematogenous and bronchogenic laryngeal tuberculosis has improved our understanding of this disease.

The bronchologists have done the most to improve our knowledge of tracheobronchial tuberculosis during the past 10 years. This phase of the disease was more or less neglected by laryngologists and phthisiologists alike. The diagnosis and treatment have improved and this means more prevention with more cures. The question is often asked, "Is there anything new about tuberculosis?" The bronchologists have given us much which is new. The phthisiologists and the chest surgeons have improved all forms of collapse therapy so much that laryngeal tuberculosis is fast disappearing as a complication of pulmonary tuberculosis.

The article by Howie, of Glasgow, on "Tuberculosis of the Larynx in Childhood" deserves much more than passing mention. His review of 159 cases thoroughly studied from every angle shows that children have tuberculosis of the larynx just as adults do. This is a definite clinical contribution to laryn-

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gology by a British confrere. The article should be read in its entirety by every laryngologist interested in tuberculosis.

Myerson[1] mentioned the danger of pregnancy in women with caseous pneumonic tuberculosis and emphasized the greater danger if laryngeal tuberculosis is also present. He showed the results in 166 cases studied at the Sea View Hospital. There were 22 deaths: Seven in women with pulmonary tuberculosis and 15 in those with pulmonary and laryngeal disease. His figures showed that the added burden of laryngeal tuberculosis was too much when pregnancy occurred. The fatal cases were nearly all cases of advanced pulmonary tuberculosis. He showed the importance of therapeutic abortion and Caesarian section to save the mother's life. The danger of anesthesia, because it lessened expectoration, was given due importance. His article had 17 references from the literature.

Lukens[2] reported the results of his study of tuberculous patients at the Jefferson Medical College Hospital and the Henry Phipps Institute. His article dealt chiefly with ambulatory cases. He regretted that the general practitioner paid so little attention to the larynx in patients with pulmonary lesions. He believed the dispensaries often diagnosed the laryngeal complications earlier and advised sanitarium care. He emphasized the importance of finding the early lesions, because the patient may not complain about the larynx. The late lesions usually produced hoarseness or aphonia. Dysphagia and odynphagia were late symptoms. Tracheotomy, artificial pneumothorax, electrocauterization, as well as many other therapeutic measures for the larynx, were well presented.

Wilson[3] based his article on 20 years' experience with tuberculous patients. He had examined and treated over 1,000 in private practice. He appreciated the fact that he sees fewer and fewer cases of laryngeal tuberculosis because the laryngeal form is being prevented. He advocated frequent examination of the larynx for tuberculous patients in order that an early diagnosis may be made. He discussed the various subjective and objective symptoms. There were 17 tables and nine figures, with 70 references. His article was very complete in every detail.

Myerson and Gilbert[4] called attention to the greater prominence given to tuberculosis of the ear in textbooks as compared to former years. They found the bovine type of tuberculosis more prevalent in countries where milk wasn't pasteurized. They presented three tables and four figures. There were 13 case reports with detailed surgical and non-surgical treatment, and 35 references to the literature. Their cases of mastoiditis were accumulated over a period of seven years and the cases of tuberculous otitis media were for the year 1938. They advised local anesthesia when mastoid surgery was required and they preferred the radical operation.

Baron[5] reported a case of laryngeal tuberculosis in a boy, age 2 years and 8 months, from the pediatric service of the Lawrence and Memorial Associated Hospitals. The patient was well studied clinically and the laboratory reports were complete. The case was undoubtedly one of laryngeal tuberculosis and complicating tracheopulmonary tuberculosis. He showed an interesting film of the upper chest, trachea and larynx. There were four references to the literature. Even without an autopsy the diagnosis was well established, as laryngeal tuberculosis is supposed to be very rare in small children, but it isn't.

Vandevere[6] reviewed the etiology, symptomatology, pathology, diagnosis, prognosis and treatment of laryngeal tuberculosis. He emphasized the importance of rest of the voice by silence, ultraviolet rays of the sun by means of the Verba laryngoscope, the use of the electric cautery, sanitarium care, etc. He quoted many authors to substantiate the use of the cautery. He described the technique of using the cautery. His six points in the summary were well chosen. He had 17 references.

Hautant[7] examined a patient, age 62 years, with a mass of swollen cervical glands on the left side of two months' standing. There was no difficulty in swallowing and no earache. There was ulceration on the left tonsil. Herpetic angina and Vincent's angina were ruled out, and the condition was diagnosed as chronic tonsillitis. All symptoms and signs pointed to such a diagnosis but the tonsillar ulceration did not fit into the picture. The tonsils were removed when the ulceration failed to respond to the conventional treatment of tonsillitis and the general health of the patient deteriorated.

Serial sections of the specimen demonstrated the tuberculous etiology of the lesion. Cachexia progressed and the patient died a short time later. No other foci of tuberculous infection were found.

The author believed the infection was primary. The trauma of the operation may have caused the local infection to become generalized. In this light, and in view of the age of the patient, abstention from surgical intervention might have been more desirable. In young individuals the presence of a tonsillar lesion of suspected tuberculous etiology, associated with cervical adenitis, is a strong indication for surgical removal of the focus, providing the general health of the patient is satisfactory.

Jouan[8] found, on the basis of a very incomplete clinical examination, that the condition of the patient had been diagnosed as tuberculous laryngitis. On X-ray examination, made for other reasons, the left lobe of the lung was found to contain a cavity, the size of a tangerine, while a hydatid cyst of similar size was seen in the right lobe. Persistent questioning elicited the information from the patient that during an attack of fever, with the maximum temperature reaching 40° C., he expectorated a thick substance, resembling egg-white, which contained membranous fragments. The author concluded therefrom that the cavity in the left lobe represented the remnant of a hydatid cyst evacuated by vomiting.

The patient underwent an operation for the cyst in the right lobe and became well. Since 1926, the author stated, mistakes of this kind had repeatedly come to his attention. For this reason he urged more painstaking examinations for patients with such cystic cavities of nontuberculous etiology who were sent to tuberculosis sanatoria. These inevitably contract the infection when exposed to that environment.

Belford[9] found that more than 100 patients had received a total of 1,000 instillations since the introduction of chaulmoogra oil for the treatment of tuberculous laryngitis. Often the oil was used together with other tested agents. About 1 to 2 cc. was applied in all directions, sufficient to cover practically the entire mucosa. The few drops entering the trachea were expelled by coughing, but if swallowed, severe gastric

irritation might result and make eating impossible for as long as three days.

The oil had a threefold action: decongestion, dissipation of infiltrations, and epithelization. Decongestion was the result of irritation which caused a degree of hyperemia. The dehydrating action of the oil reduced the infiltrative edema. Epithelization was promoted by the potent bactericidal action of the agent. The oil was not as good a general bactericide as many other disinfectants but it had a striking potency against tubercle bacilli, as demonstrated by a series of culture experiments. Local anesthesia was required only for embrocation.

Laryngeal ulcerations of slight depth disappeared permanently. Infiltrative and edematous lesions, however, may reappear even during treatment. In other words, the antiseptic action upon the mucosa frustrates the establishment of new ulcerations (possibly, also, the lubricating action was a beneficial factor). The oil was of no avail against hematogenic reinfection. Chaulmoogra oil has been particularly beneficial in the cases of mild odynophagia which one sees in ambulatory clinics. Reference was made to Fenton's work on tissue reaction to chaulmoogra oil in the *Archives of Otolaryngology*, 32:429-433, 1940.

Belford[10] presented a review article. Under the heading of treatment, the author announced that he had used chaulmoogra oil for treatment upon the suggestion of the phthisiologist, Tisi Neto. The results will be described in the near future.

Duarte[11] found that ultraviolet rays were used in treating laryngeal lesions of 30 unselected patients with severe forms of pulmonary tuberculosis in most instances. Radiation was applied directly to the lesions by means of the Cemach lamp, which consisted essentially of a curved tube with a small mercury vapor tube in the tip. The first treatments, lasting five to 20 seconds, required no local anesthesia; as the applications become prolonged to a maximum of five minutes, a 2 per cent neotutocaine was used. Intervals between treatments were from one week at the outset to four and five days later on. No local or general reactions were noted, nor was there any rise in temperature.

The treatments were chiefly beneficial for dysphonia and dysphagia. Dysphonia was cured in 33 per cent, improved in 50, and not influenced in 17. Dysphagia was cured in 100 per cent. Patients with a slight infiltration were cured in 63 per cent; improved in 31; with no benefit in six. Patients with severe infiltroulcerative lesions were cured in 14 per cent; improved in 64 per cent; and no change in 22 per cent. results for the entire group of 30 were: cured, 12 (40 per cent); improved, 14 (47 per cent); and condition unchanged, four (13 per cent).

In 52 per cent of the patients with laryngeal tuberculosis, the lesions were silent and were not noticed by the patients themselves. The author urged systematic laryngological examinations as a routine for all patients with pulmonary tuberculosis as these patients have a good chance of recovery if the lesions are discovered early enough.

Penna[12] regarded tuberculosis as a general infection, with laryngeal lesions as only one of its localizations, and not a complication of pulmonary tuberculosis. The influence of pulmonary processes on the laryngeal lesion cannot, of course, be denied as the larynx was actively involved in the coughing by which all secretions were expelled. It was true that laryngeal lesions were most often found in patients with chronic pulmonary tuberculosis but this meant only that the immunological equilibrium that allowed the condition to take a chronic course was at some time disturbed, with the result that new active foci were established in localizations where the infection had been latent. The reason that some cases responded to purely pulmonary treatment was that such treatments were almost always combined with a general treatment that would benefit any localization. In order to bear out his views, the author described three illustrative cases.

Vivoli and Bertelli[13] reported a total of 80 excised tonsils which were examined; 20 were from tuberculous patients, and 60 from patients without clinical infections, who lived in the home of, or were closely related to persons with active processes. Three of the 20 specimens contained tuberculous lesions which were not visible at the examination. This proportion of 5 per cent was greater than the percentage of incidence (12.75 per cent) reported by a previous investi-

gator, Aufrecht. The other series of 60 specimens was negative. It was interesting to note that among the tuberculous patients with positive findings, there was a child, age 8 years. The usual age of incidence of these lesions is between 20 and 40 years. Histological examination furnished no new evidence for settling the question of air-borne versus hematogenic infection. A routine histological examination should be made of all tonsils removed from patients suffering from severe adenitis.

Bueno[14] found that surgery in the terminal stage of laryngeal tuberculosis had disappointed the hopes put in it at its introduction. The author now injects 90 per cent alcohol into the superior laryngeal nerve, laid bare by the method of Beck, in a quantity sufficient to bring the nerve to the thickness of a fine thread. Then forcipressure is applied by means of a Kocher forceps. Nervous conduction was interrupted in this manner. The nerve may recover at the end of eight months or a year. As a result of the injection and application of pressure, the painful dysphagia was relieved, and the patient was able to rid himself of the purulent mucous filling the laryngeal cavity. The enhanced well-being inspired new hope in the doomed patient and lightened his end. Five cases were cited in which the new method was tried. One patient died after four days, but in the other four cases satisfactory and permanent relief of painful dysphagia was obtained.

Leshchinsky[15] considered his case rare and misleading. It was also a proof of the necessity of phthisiolaryngological examination. On the left lateral surface of the epiglottis there was a tumor on a pedicle the size of a plum. On the lingual tonsil, likewise on the left side, there was another tumor of oval form, somewhat smaller in size. Under local anesthesia of a 10 per cent solution of cocaine, the tumor was removed by sections from the lingual root. There was no hemorrhage. The postoperative period was painless. Ten days later the tumor was excised from the epiglottis.

Microscopic examination of the tumors showed chronic proliferating productive inflammation, accompanied by the formation of multiple infiltrates and nodules composed of large endothelial cells with vesicular nuclei. In certain places these cells had the aspect of "gigantic" ones characteristic of tuberculosis. The diagnosis was tuberculosis.

From the form and, to a certain extent, the site and general state of the patient, falsely led one to suspect a benign tumor such as a fibroma. The form, consistency and site of the tumor on the pedicle were in favor of such a diagnosis and this was the probable reason for excision without a detailed general physical examination of the patient. The tumors were sent to the pathological-anatomical laboratory for confirmation of the diagnosis and the result was a great surprise to the diagnostician.

Voznesensky[16] believed tuberculosis of the upper respiratory tract was the gravest complication of pulmonary tuberculosis. Certain forms of pulmonary tuberculosis, in the inapperceptive phase of their course, were diagnosed generally only after complications in the pharynx and larynx became apparent. These forms of laryngo-glottic-pulmonary tuberculosis often simulated nonspecific angina, acute laryngitis, catarrh of the throat, etc. For control of tuberculosis of the upper respiratory tract, the following means were being proposed: *1.* Obligatory course of phthisiolaryngology for all phthisiatrists. *2.* Better instructions for otolaryngologists in the sphere of diagnosis, clinical aspect and therapy of tuberculosis of the upper respiratory tract. *3.* Preparation of phthisiolaryngologists from the ranks of phthisiatrists and otolaryngologists. *4.* Considerable increase in the number of hours in the course of phthisiolaryngology. *5.* Perfectioning of phthisiolaryngologists through additional courses.

Zobin[17] found the difficulty in the controlling of dysphagia in tuberculosis of the upper respiratory tract was complicated by the following conditions: *1.* Impossibility to procure complete rest for the affected organ, especially to the larynx, due to coughing, sputum, swallowing and speech. *2.* Difficulty in fixation of the analgesic on the painful area of the mucosa, where it was carried off by excessive secretion of the mucous membrane. *3.* Innervation of the mucous membrane of the oral cavity, glottis and larynx by various sensitive nerve (trigeminal, linguoglottic and branch of the vagus). The results of five years' experience in the application of alcohol-tannic-anesthetizing solutions in an extensive clinical experience gave the author the right to consider it as one of the most effective methods in the treatment of tuberculosis of the upper respiratory tract in dysphagia. On the basis of experi-

mental investigations, it may be said that the above solution was a powerful bactericide against streptococci, staphylococci and Koch's bacilli. Even in protracted applications to the mucous membrane it did not produce burns; the application of the solution may be used in acute and chronic forms of tuberculosis of the respiratory tract.

Binstock[18] found his clinical material for 10 years (1928-1938) showed that fresh, initial infiltrative and pneumonic tuberculous processes in the lungs, even in the phase of an already formed cavern, were rarely accompanied by contact tuberculosis of the larynx. The number of such cases did not exceed 5 per cent of all cases of laryngeal tuberculosis of sputum origin. Still rarer was tuberculosis of the larynx encountered in cases of lobar and lobular tuberculosis with violent course and lethal issue (clinical material showed only 1 per cent). The remaining 94 per cent of all cases of contact tuberculosis of the larynx were found in marked forms of protracted, chronic fibrinocavernous pulmonary tuberculosis. The material of the laryngeal department of the Moscow District Institute for Tuberculosis showed that laryngeal tuberculosis was found with pulmonary tuberculosis in the first stage in 5.5 per cent, II in 24.4 per cent, III in 64.7 per cent. In bilateral affections of the larynx the progress of the process was usually more active on the side where the caseous-destructive process of the lung was more marked. The nature of all these facts has not been adequately explained in the up-to-date special literature so far. The author was of the opinion that the theory of relativity existing between laryngeal and pulmonary processes demanded extensive experimental research, although it justified itself by the clinical material.

Kravchenko[19] found that peritonsillar infiltrations of a tuberculous character appeared mostly in the tuberculous cavity of the mouth, pharynx, cervical and submaxillary lymphatic glands. Clinical manifestations of the disease were the following: *1.* The temperature was 36.5-37.5°. *2.* The peritonsillar tissue was infiltrated to such a degree that it firmly adhered to the opposite side. *3.* During the first four-five weeks the surface of the infiltration was a pale pink mucous membrane, hard as wood to the touch and painless during probing. *4.* There was absence of pain during eating and

drinking. *5.* There was a slight nasal twang. *6.* The head was carried in the erect position and the patient did not notice the swelling in the mouth because it did not hinder him. In six-seven weeks the mucous on the surface of the infiltration began to acquire a dark blue hue and in eight-ten weeks from the time of its appearance (visible infiltration) it became pale again and softer. After a time it may disintegrate if treatment is not administered. The diagnosis of tuberculous peritonsillar infiltrations was based upon etiological data, clinical aspects, and the whole complex of investigations was supplemented by microscopic examination of the affected tissue. The treatment consisted of the galvanocautery. Disintegration should not be allowed, because it was followed by a large, deep, painful wound with ichorous odor, and the patient often dies from exhaustion and intoxication. The galvanocautery so far has always given good results.

Spencer, Whitehead, Black and Duffner[20] reported their results from the treatment of experimentally infected middle ears of rabbits with sulfapyridine. The administration of the drug was not started until after the ears were inoculated, so that no immunity was produced prior to infection. The sulfapyridine was injected into the veins of the rabbits' ears in order to avoid gastroenteritis from the oral administration. The treated animals lived a little longer than the untreated controls, but the histopathology of the treated and untreated ears was about the same. They showed four microphotographs. There were 10 references. In conclusion they said the results from treatment were not as encouraging as they had hoped.

Dworetzky and Risch[21] showed a very gratifying decline in the incidence of laryngeal tuberculosis. Their Table 1 showed a reduction from 25.6 per cent in 1914 to 3.6 per cent in 1941. They attributed this to the ever-increasing educational campaigns, improved methods of examination and improved methods of treating pulmonary tuberculosis. They presented nine differential points regarding bronchogenic and hematogenous cases. There were three case reports, six photographs of the larynx, nine Roentgen-ray films of the chest, five tables and four references in the article.

Spencer[22] reviewed the laryngeal complication of pulmonary tuberculosis and emphasized the important pathological

changes in the tuberculous larynx. The important methods of treatment were listed and discussed, such as cauterization, vocal rest, heliotherapy, oil sprays, injection of alcohol, ionization, chemotherapy, tracheotomy, collapse therapy, amputation of the epiglottis, gastrostomy, etc. The most important thing was the prevention of laryngeal disease by early diagnosis and early treatment of the pulmonary tuberculosis. The chest physicians and surgeons have accomplished almost a miracle in this field. The different methods of collapse therapy deserve a great deal of credit for the prevention of laryngeal tuberculosis.

Spencer, Whitehead and Duffner[23] reported the results of their experimental treatment of guinea pigs with sulfapyridine. The guinea pigs were inoculated with human tubercle bacilli. The treatment was not started until the lymph nodes had enlarged. An equal number of pigs were used as controls. The sulfapyridine was given by mouth. Many of the pigs died. These showed at autopsy an extensive tuberculosis, especially in the untreated animals. In the treated animals which survived there was slight improvement, but not enough to justify much optimism. They encountered the same difficulty which most investigators have when they tried to get a drug to penetrate a bacillus, the content of which is 40 per cent fat. There were eight illustrations and three references in the article.

Myerson[24] found tuberculosis of the trachea and bronchi the most discussed phase of disease of the chest today. His paper was based on clinical observations and deductions made in a series of 572 consecutive bronchoscopies of tuberculous patients at the Sea View Hospital. He found a specific lesion in the trachea or bronchus of 152 of the patients. The incidence was 4 per cent. He said the bronchologist observes the lesions from the very beginning, while the pathologist sees only the terminal lesions. He discussed the different lesions and described the progress these may make, either in healing or in spreading until a fatality results. There were eight figures and six case reports. Many types of tracheobronchial lesions were discussed, such as ulcerogranuloma, granuloma, suppuration, fibrosis, stenosis, atelectasis, etc. Except for the granuloma, secondary to a perforating mediastinal gland, the bronchial lesion was always secondary to an ulcerous lesion

in the lung parenchyma. Tuberculosis of the trachea and bronchi followed a definite course, the various stages of which were predictable according to Myerson. He found pneumothorax was superfluous once a bronchial lesion had developed.

Mikhlin[25] found that silver preparations, by Moiseev's method, were neither a specific remedy nor a cure for tuberculous ulcers of the upper respiratory tract, but due to their bactericidal properties they affected secondary infections and helped to reduce or destroy the perifocal inflammatory symptoms. These also reduced the annoying subjective sensations, such as dryness, rasping sensation in the throat and dysphagia. The disappearance and reduction of perifocal symptoms were obtained in 32 per cent of the patients with tuberculous ulcers of the upper respiratory tract, and in 16.6 per cent of the patients with ulcers of the larynx. The success of the therapy depended upon the accessibility to the ulcerated area. Silver preparations were absolutely harmless for the upper respiratory tract and did not affect the general condition of the patient. The method of preparation and application was extremely simple. Prof. Moiseev's preparations were considered effective and were recommended for the treatment of ulcerous tuberculosis of the upper respiratory tract.

Weiss[26] believed tuberculous affections of the mouth were generally localized on the gums of the upper jaw. Acute infectious processes of the oral cavity especially played an important pathogenetic rôle in tuberculous affections of the mucous membranes. In the pathogenesis of tuberculosis of the mucous membranes of the mouth, simultaneously with the intracanalicular tract, the hematolymphogenous dissemination had an enormous significance, and the submaxillary lymphatic glands were often the source of tuberculous infection of the organs and tissues of the oral cavity. Gangrenous teeth may be conductors of tuberculous infection in the jaw. Banal odontogenous infection may serve as a pathogenic factor in the development of tuberculosis of the mucous membranes of the mouth and gums. Hygiene of the oral cavity in general, and in tuberculous patients in particular, was the main prophylactic factor. In differential diagnosis one must keep in mind that the hypertrophic forms of lupus of the mucous

membranes of the nose and gums, and also tuberculosis of the jaws, may clinically present the aspects of a sarcoma.

Libin and Travushkina[27] have tabulated the following: *1.* The clinical material presented more cases of tuberculosis of the soft palate in ulcerous form than any other. *2.* If tuberculosis of the soft palate or other organs of the oral cavity cannot be diagnosed through a tuberculous process in the lungs, special attention should be given to general changes brought about by von Pirquet's reaction and Koch's test. *3.* In affections of the soft palate, with absence of pulmonary tuberculosis, one must always remember the possibility of the exogenous factor in tuberculous infection of the oral cavity. *4.* Therapy of metastases in the soft palate, with weak stimulants, gave good results in disseminated pulmonary tuberculosis. *5.* In macroscopic examination of the soft palate and lingula, on cadaveric material, tuberculous affections of the soft palate were found in 5.5 per cent of the cases and of the lingula in 0.9 per cent of the cases. *6.* In microscopic examinations of the soft palate and lingula, on cadaveric material, tuberculosis of the soft palate was found in 17 per cent of the cases, and of the lingula in 14.2 per cent of the cases. *7.* It was histologically determined that in 12 cases of tuberculosis of the soft palate, the lingula was free of tuberculosis in two cases, and in two other cases the aspect did not conform with the affections of the soft palate. *8.* Out of 12 cases of tuberculosis of the soft palate, histologically determined, four cases of tuberculosis were not determined macroscopically.

Soares[28] observed a sudden amelioration of pain in a case of grave odynophagia directly following a pleuromediastinal rupture which produced moderate emphysema of the cervical region. He proposed to reduce cervical emphysema in some patients with disorders of deglutition resulting from tuberculosis of the larynx by means of injection of 80 to 100 cc. of air with a Forlanini apparatus. He did not state in what particular area of the neck the air should be injected. He reported 17 cases where this procedure yielded more or less permanent results. The procedure was simple, caused no pain and did not in any way endanger the patient. Injections were repeated when the effect wore off. The results, he held, were more satisfactory than those obtained with an infiltration of

alcohol. Soares was not sure whether the beneficial effects were due to a phychological reaction on the part of the patient or, which is not impossible, to a reflex caused by distention of subcutaneous cellular tissue.

Monteiro[29] discussed the literature of the subject and then reported his own case and accompanied it with several illustrations. The patient, a male, age 22 years, weighing 75 kg. (165 pounds), came to the hospital complaining of difficulty in swallowing, which had gradually become worse during the preceding six months. The throat presented vegetations predominating on the uvula, extending to the posterior pillar and the side walls of the pharynx but sparing the tonsils. There was no inflammation around the growth. The uvula was three to five times its normal size, without deposits of secretions. The Wassermann test was negative. The growth was diagnosed as a basocellular epithelioma, with several other physicians concurring in the diagnosis. A biopsy, made as a routine matter, showed, however, that the lesion was a typical tuberculous granuloma. This was also the opinion of Prof. Penna de Azevedo. X-ray examination of the lungs by the author proved negative. Repeated Roentgenologic examinations by other physicians were negative, as was examination of the eschar. The skin reaction was positive and the temperature normal. General treatment was instituted. A second Wassermann test was ++. A second biopsy confirmed the findings of the first. Subsequent Roentgenologic examinations by several prominent specialists gave transparent pulmonary fields. Koch's bacillus was not detectable in any of the specimens obtained by a total of four biopsies. Injection into laboratory animals was invariably negative. The diagnosis, though based exclusively on the histopathological findings, had been confirmed beyond a shadow of a doubt by a number of specialists. The patient remained under observation for five months, at the end of which time he insisted on returning to the interior of the country. Treatment consisted in the application of lactic acid and, for a while, heliotherapy. The vegetative appearance of the lesion changed very little; the uvula had almost completely disappeared as the result of the successive biopsies. Only the posterior pillar had become cleaner and the appearance probably would have improved with time if the patient had remained in the hospital. At the time of discharge he had gained 3 kg.

González Rubio and Marchal Ceballos[30] reviewed the records of 6,278 patients who had presented themselves at the tuberculosis dispensary of the district of the University of Madrid in a single year (1935), which showed tonsillar histories in 150 instances. The age distribution was as follows: *1.* under 12 years, 2,000; *2.* 12 to 26 years, 2,221; and *3.* over 26 years, 3,051. The incidence was highest in Group 2, 43 per cent, with Groups 1 and 3 following with 37 and 20 per cent, respectively. Group 1 exhibited a predominance of males (60 per cent), with the largest single group (14 per cent) around the age of 8 years. Hypertrophic tonsils were seen in 58 per cent, with 27 per cent associated with intense inflammatory reaction, and 15 per cent with cryptic infection. It was found that 37 per cent of the children had had several attacks of tonsillitis; 27 per cent reported the onset coincidental with the onset of pulmonary symptoms; in 21 per cent the tonsillar signs preceded the pulmonary symptoms by three to six months. Five per cent gave histories of intestinal disorders, but such localizations could not be confirmed.

In Group 2 the incidence was higher among females (58 per cent). Hypertrophy of the tonsils was dominant in 37 per cent, 36 per cent of which cases also showed inflammatory reaction, with 16 per cent presenting crypts filled with purulent matter. Early histories of tonsillar symptoms were reported by 34 per cent, simultaneous pulmonary and tonsillar symptoms by 27 per cent; in 20 per cent, tonsillar symptoms were recurrent. Intestinal disturbances were reported by 12 per cent and confirmed in 7 per cent by X-ray. The highest incidence was at the age of 18 years (11 per cent).

In Group 3 the incidence was approximately equal in the two sexes, the age most often affected being 30 years (23 per cent). Tonsils were hypertrophied and sclerosed in 67 per cent, with only 11 per cent of these exhibiting inflammation. Early histories of tonsillitis were given by 55 per cent, 12 per cent being recurrent attacks; in 23 per cent the symptoms in the two locations appeared at the same time. Digestive symptoms reported by 18 per cent were confirmed in 13 per cent.

Alexander[31] summed up his experiences of 20 years' work at the Deutsches Haus Sanitarium at Agra, Switzerland. He

stated: *1.* Primary tuberculosis of the larynx had not been proved to date. Isolated tuberculosis of the larynx was rare. Clinically, the most important form was chronic tuberculosis of the larynx secondary to pulmonary tuberculosis, resulting either from contact infection or, rarely, infection through the blood stream. In all his experiences he had had only one case of hematogenic infection from a latent focus. *2.* Tuberculosis of the larynx was a disease of the second to the fourth decade of life. Its incidence was three times as high in men as in women, an exception being the teacher group, where the proportion was 1:1. At necropsy it had been diagnosed in 20 to 30 per cent of all cases of tuberculosis. *3.* There were four different forms: *a.* infiltration; *b.* ulceration; *c.* perichondritis; *d.* tuberculous tumor. Lupus of the larynx held a place of its own, as it was hardly ever associated with pulmonary tuberculosis. *4.* Owing to paucity of symptoms at the onset, examination of the lungs should in every suspected case have been followed by a meticulous examination of the larynx. Conversely, persistent laryngitis (catarrh) called for X-ray examination of the chest. *5.* The diagnosis was usually established on the basis of indirect laryngoscopy alone; the Killian position was here important. Fluoroscopy and Roentgenography were valuable aids.

De Martini[32] in a previous study (1938) showed that Koch's bacilli were extremely rare in tuberculous tonsils only in two out of 15 tonsils examined). Biological tests were as a rule negative, no matter how severe the specific lesions. If the inoculation took at all, the process was greatly attenuated. It was evident that the human tonsils had a positive tropism for this bacillus, as indicated by the fact that latent lesions had been found by a very great number of scientists doing research. There was evidence of a bacteriolytic action against Koch's bacillus. Experiments were undertaken to test this action. Ground tonsil tissue, tuberculous and nontuberculous, of controlled sterility, was distributed in flasks, to which were added small pieces of tubercle bacilli cultures. The colonies developed rapidly in nontuberculous juice. In tuberculous juice, development was slow to begin with and ceased altogether after a while. Controls showed very rapid development. It appeared, therefore, that juice of tonsils with latent tuberculous lesions had a marked bacteriostatic power, varying with the amount of juice employed and the

extent of the lesion, the more severe ones exhibiting greater bacteriostatic action.

Carpenter[33] reported the clinical features of tracheobronchial tuberculosis as follows:

*1.* Asthmatoid wheeze. *a.* Might be heard by oral auscultation. *b.* Varied in intensity. *c.* Persisted for long periods of time, after expectoration. *d.* Loudest at site of lesion. *e.* Might transmit vibrations to palpating hand. *f.* Might be present only on exertion or forced expiration.

*2.* Persistent ronchi.

*3.* Paroxysmal cough with tenacious sputum.

*4.* Dyspnea was out of proportion to vital capacity.

*5.* Constant tendency to clear throat.

*6.* Marked variation in amount of sputum.

*7.* Persistently positive sputum. *a.* With quiescent tuberculosis. *b.* With no parenchymal involvement. *c.* After adequate collapse therapy.

*8.* Hemoptysis with quiescent pulmonary involvement.

He showed a table of Roentgenologic findings also worth while. He showed four other tables. He gave four important conclusions. There were 11 references.

Roberts[34] described a method of injection of the larynx for tuberculosis which he found very useful in the East Indian medical service. He injected the interior of the larynx with a 1-to-60 solution of phenol in glycerine and water. He injected under the mucosa and used 0.5 cc. He recommended the following solution: ℞ — Phenol, ʒ ss; glycerine, ʒ ii; aqua dist., q.s. ℥ iv; M.

A local anesthetic may be added to this. He advocated going through the skin with the needle and injecting near the ventricle. He said surface applications do not penetrate the deeper tissues. His method reached the deep tissues.

Bailey[35] discussed the incidence, signs and symptoms, diagnosis and treatment in his article. He reported and commented on one case. There were 11 references in his article. The patient almost recovered from pulmonary tuberculosis and then developed an ulcer of the trachea. One application

of 30 per cent silver nitrate solution made this heal in a few months. He advocated earlier bronchoscopic diagnosis and treatment.

Kernan and Cracovaner[36] reported their results from treatment of tracheobronchial tuberculosis and reported two cases. They emphasized ulcerations, granulations, fibrous strictures, swollen mucous membranes, wheeze, positive sputum, hemorrhages, severe dyspnea and persistent cavities as some of the important objective and subjective symptoms. They discussed their methods of treatment with silver nitrate 10 per cent, mercury vapor lamp, etc., and tabulated the number of cases treated by each or several methods.

Shaw[37] discussed the physical signs, Roentgenologic signs, diagnosis, therapy, etc., of tracheobronchial tuberculosis before the Texas State Tuberculosis Association.

Amberson[38] reported four women who showed turgescence of tuberculous bronchial lesions during the menstrual period. He found tuberculous tracheobronchitis more frequent in women than in men and thus had an opportunity to observe the swelling of the stenotic lesions during menstruation. He believed the estrogens circulating in the blood at this time may have explained the aggravated symptoms.

Howie[39] gave a historical review of the literature with a description of the material examined. The group comprised 159 children. His Table 1 gave sex and age groups from 6 months to 17 years. Table 2 gave the type of lung disease in relation to sex and age of sickening. He showed the type of infection in 90 "open" cases and the laryngeal disease in relation to the pulmonary disease. He showed seven tables and eight plates. He discussed signs, symptoms, types of lesions, treatment, results, nontuberculous lesions, postmortem specimens and routes of infection. There were eight important points in the summary, and 19 references. The article was long and very complete.

The important thing about Howie's article was that it showed conclusively that laryngeal tuberculosis can and does exist in children, and without the usual signs and symptoms met with in adults. He was surprised to find so many lesions in the larynx in children. He found "open" phthisis in those children with laryngeal lesions. He believed bovine and

human infection were equally prone to produce laryngeal disease. The lesions corresponded to those found in the adult larynx.

Hulse[40] found hoarseness a frequent symptom in patients with pulmonary tuberculosis even when laryngeal tuberculosis could not be demonstrated. He reviewed the nerves and muscles of the larynx and showed how these structures may be involved extrinsically or intrinsically to produce hoarseness. He said only a small percentage of patients with pulmonary tuberculosis who have hoarseness have specific involvement of the larynx. He emphasized that the cause may be extrinsic as well as intrinsic.

Rothman and Mapes[41] presented seven figures of Roentgenograms of the chest showing the chest pathology of their two cases. They had 22 references. They said massive unilateral pulmonary collapse therapy was not indicated when tracheobronchial ulceration was present. The collapse therapy added to the difficulty of raising sputum when tracheobronchial lesions were present. They advocated pneumonectomy for severe uncontrolled bronchiectasis.

Davenport[42] has written and published a long article showing the incidence, types of lesions, Roentgen pathology, course, prognosis, treatment, dosage and results. There were 10 case reports and six figures to illustrate the paper. All 10 cases were fulminating and two deaths occurred. He believed obstruction was the gravest symptom, either partial or complete, with retained secretions. Six of their cases improved with radiation therapy. There were 14 references.

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**Physicians' Building.**

## CANCER OF PARANASAL SINUSES.*†

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The purpose of this report is to present a review of the clinical findings in a detailed study of 127 cases of primary cancer originating in one of the paranasal sinuses. After some thought, it was decided to exclude from consideration all benign neoplasms, all primary bone tumors, as well as all growths which secondarily invade the bony cavities under consideration. Much of the pertinent medical literature seems to lose value because of the author's attempt to include all types of sinus neoplasm in his series. As many as 37 different varieties of tumor are known to occur in and about the nasal passages. In going over the material at Memorial Hospital, it was apparent that the inclusion of any but the proven cancers would make this report too lengthy and would detract from its value.

The material used in the statistical portion of this paper is made up of the patients admitted to Memorial Hospital for this disease during the 10-year period between 1928 and 1938, and consists of a consecutive series of 127 cases. During this period our hospital admitted a total of 26,062 new patients, so that the admission incidence for paranasal sinus cancer was 0.44 per cent (see Table 1). These figures indicate that cancer primary in the paranasal sinuses is a comparatively rare disease.

Due to the usual rather advanced nature of the patient's disease on admission, it is sometimes quite difficult to determine the exact location of the primary tumor. But from Table 2 it will be seen that primary cancer occurs in the antrum of Highmore much more frequently than in all the other parasanal sinuses combined (105 to 22). The ethmoid sinus is next most frequently involved (seven cases). Third is the frontal sinus (four cases). In only one case was the primary tumor definitely located in the sphenoid, and that was determined only at autopsy (see Fig. 1). This leads one

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to suspect that cancer of the sphenoid sinus may go unrecognized during life or be erroneously diagnosed simply as "brain tumor."

Paranasal sinus cancer, like so many of the head and neck neoplasms, occurs much more frequently in the male than in the female sex (see Chart 1). In this series the proportion

TABLE 1. INCIDENCE OF OCCURRENCE OF CANCER OF PARANASAL SINUSES, MEMORIAL HOSPITAL, 1928-1938.

| | |
|---|---|
| Patients admitted | 26,062 |
| Patients with paranasal sinus cancer | 127 |
| Per cent of total | 0.44 |

Table 1. Paranasal sinus cancer is a relatively rare form of cancer and makes up only 0.44 per cent of the cases admitted to the Memorial Hospital.

A B

Fig. 1. (A) This patient had a diagnosis of brain tumor before a node appeared in the right upper neck and was removed and proven to be epidermoid cancer. (B) Autopsy specimen showing primary cancer of the sphenoid sinus.

is 81 males to 46 females, nearly two to one. The average age of the patient was 54 years, the youngest being a boy of 4 years, and the oldest a female of 83 years. Four patients in this series were under 15 years of age. There were none between the ages of 14 and 27 years, leading one to suspect that this period is one of limited susceptibility. The largest

number of patients developed paranasal sinus cancer between the ages of 60 and 70 years.

*Diagnosis of Paranasal Sinus Cancer:* An accurate history will not often help in establishing a diagnosis of cancer of the cranial sinuses. This is due to the anatomy of the parts,

TABLE 2. LOCATION OF THE TUMOR IN CANCER OF PARANASAL SINUSES.

| | |
|---|---|
| Antrum | 105 |
| Ethmoid | 7 |
| Frontal | 4 |
| Sphenoid | 1 |
| Antrum and ethmoid | 6 |
| Antrum, ethmoid and frontal | 1 |
| Ethmoid and frontal | 2 |
| Ethmoid, frontal and sphenoid | 1 |
| | 127 |

Table 2. The antrum of Highmore is five times more susceptible to cancer than the other paranasal sinuses combined.

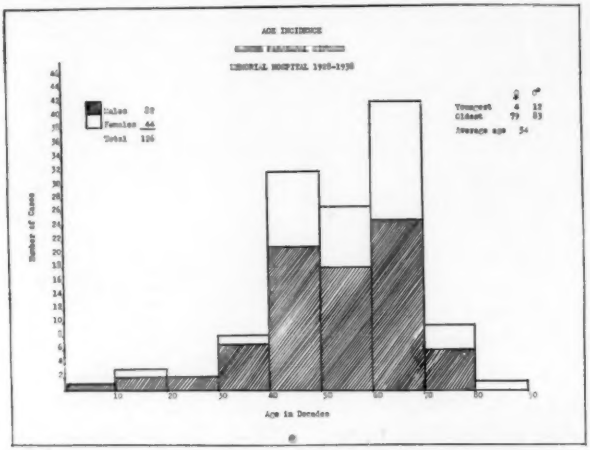



Chart 1. The proportion of males to females is two to one. The average is 54 years; and the largest number of patients developed paranasal sinus cancer between the ages of 60 and 70 years.

which permits them to harbor slowly growing cancer for quite a period of time before attention is called to the process by the most frequent first symptom of the disease; namely, pain (see Table 3). Swelling of the cheek, nasal obstruction and nasal bleeding are the next most frequent complaints,

but these are all symptoms of advanced rather than early cancer. The usual symptoms of "chronic sinusitis" were noted in this series about as often as they occur in the general population. From this material, therefore, it cannot be deduced that low-grade sinusitis, excessive use of tobacco, nose and throat infections, asthma, etc., have any predisposing influence on the inception of cancer of the paranasal sinuses.

The facial appearance of a patient suffering from a moderately advanced cancer of the antrum of Highmore is often

TABLE 3. ANALYSIS OF SYMPTOMS IN A STUDY OF 127 CASES OF CANCER OF PARANASAL SINUSES.

| | | Frequency as First Symptom | Frequency as Second Symptom | Occurring as Symptom During Course of Disease |
|---|---|---|---|---|
| Pain | Cheek | 14 | 32 | 8 |
| | Frontal region | 9 | 4 | 2 |
| | Upper jaw | 13 | 3 | 2 |
| | Eye | 4 | 2 | 1 |
| Swelling of cheek | | 35 | 23 | 21 |
| Nasal obstruction | | 15 | 9 | 20 |
| Nasal bleeding | | 13 | 5 | 4 |
| Nasal discharge | | 5 | 10 | 2 |
| Swollen alveolar ridge | | 5 | 4 | 3 |
| Protrusion of eye | | 7 | 3 | 12 |
| Impaired vision | | 2 | 3 | 5 |
| Lacrimation | | 1 | 2 | 5 |
| Headaches | | 1 | 2 | 2 |
| Ulceration, roof of mouth | | 4 | 1 | 0 |
| Growth, roof of mouth | | 3 | 0 | 0 |
| Sore throat | | 1 | 0 | 0 |
| Ulceration, malar region | | 0 | 3 | 4 |

Table 3. Pain is the most frequent first symptom of paranasal sinus cancer, and swelling of the cheek is next in order of frequency. No symptoms of early disease were elicited in this study.

quite characteristic (see Fig. 2). There is usually a moderately tender swelling or prominence of the soft tissues of the affected malar region, and occasionally a slight edema of the lower eyelid, and a purulent discharge from the region of the inner canthus. The palpebral aperture is noticeably narrowed and a proptosis or an upward displacement of the globe is often noted when disease or infection has penetrated the orbital fossa. Often on palpation of the antrum by pressure exerted upward and inward with a finger in the gingivobuccal gutter one is able to elicit a definite tenderness. Occasionally, too, the anterior wall of the antrum is so thinned by

disease that moderate pressure actually invaginates the wall, causing a sensation similar to that produced by depressing the surface of a pingpong ball.

The skin about the nares of the affected side is likely to be reddened, cracked or even ulcerated by the nasal discharge and frequent use of a handkerchief. Although nasal discharge may be profuse, there is usually no offensive odor until ulceration into the mouth has occurred and secondary saprophytic infection has been superimposed. The patient's voice usually has the "stuffy" quality associated with a "head cold."

In the examination of a large number of Roentgenographic studies carried out as a part of the patient's original clinical

TABLE 4. RADIOGRAPHIC DIAGNOSIS IN CANCER OF PARANASAL SINUSES. STEREOSCOPIC ROENTGENOGRAMS WERE TAKEN IN 112 CASES.

| | No. of Cases | |
|---|---|---|
| Cancer | 36 | 83% |
| Bone destruction | 57 | |
| Cloudiness | 12 | 13% |
| Bony irregularity | 2 | |
| Infection | 1 | |
| Negative | 4 | 4% |
| Total | 112 | |
| DIAGNOSIS — Positive | 83% | |
| DIAGNOSIS — Suggestive | 13% | |
| DIAGNOSIS — Negative | 4% | |

Table 4. Stereoscopic Roentgenograms were diagnostic in 83 per cent of the patients studied.

investigation, it becomes evident that on admission many of our patients were in a very advanced stage of their disease. Suitable stereoscopic sinus Roentgenographic studies were carried out in 112 instances, and a positive report of cancer was returned in 83 per cent of the series. This diagnosis was based on the finding of bone destruction, which is indicative of a late stage of the disease process (see Table 4).

Biopsy remains the most positive means of establishing a diagnosis. When the disease is found ulcerating into the nasal passage or gingivobuccal gutter, a formal biopsy may be readily obtained. Otherwise, an aspiration biopsy is of the utmost value in differentiating between a benign and a malignant process (see Figs. 3A, 3B, 3C). A biopsy obtained by

surgical exposure of the sinus should be reserved for those few early cases in which the first two procedures fail to reveal the true nature of the disease. In the present series of 127 cases, the preoperative diagnosis was established in 39 instances by aspiration biopsy and a negative report was obtained in four cases.

Cancer of the paranasal sinuses in the great majority of cases (89 per cent) is of the squamous or epidermoid type.

Fig. 2. Case M. B.: Showing the characteristic appearance of a patient with cancer of antrum of Highmore. (1) Puffy prominence of the malar soft parts. (2) Slight edema of lower eyelid. (3) Narrowed palpebral aperture. (4) Proptosis. This patient is alive and well eight and one-half years.

Sixty per cent of the epidermoid carcinomata are found to fit into the Grade 2 group (see Table 5). A Schneiderian type of epidermoid carcinoma was noted 12 times, while transitional cell carcinoma was the histologic diagnosis in seven instances. Spindle cell carcinoma and lymphoepithelioma each occurred twice.

In 11 cases, or 9 per cent of the series, the neoplasm was an adenocarcinoma; and spindle cell sarcoma was noted in two cases, or a little over 1 per cent of the series.

Fig. 3A. Cancer of antrum, aspiration biopsy. Approach through the gingival buccal gutter at the first molar level. For cancers situated in anterior-inferior portion of the antrum.

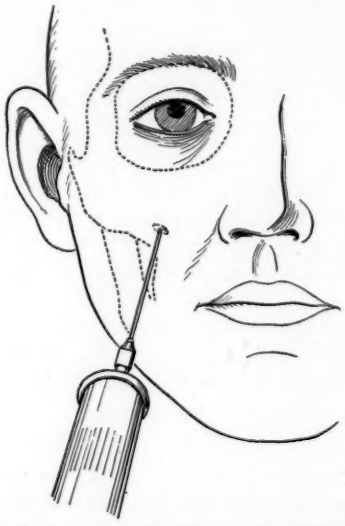


Fig. 3B. Cancer of antrum, aspiration biopsy. Anterior approach through the skin of the cheek. For cancers located in superior-anterior portion of the antrum.

*Metastases:* From a review of the literature, it appears that many physicians are of the opinion that cancer of the paranasal sinuses is for the most part a localized disease which rarely metastasizes. This has not been our experience.

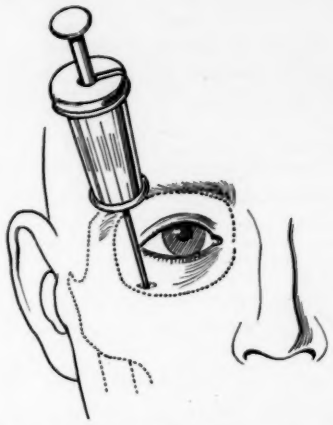


Fig. 3C. Cancer of antrum, aspiration biopsy. Approach through the floor of the orbit—for tumors involving the orbit.

TABLE 5. THE HISTOPATHOLOGY IN 121 CASES OF CANCER OF PARANASAL SINUSES.

| | | | |
|---|---|---|---|
| 1. Epidermoid carcinoma | | | 108 |
| a. Squamous or "epidermoid" | | 85 | |
| Grade 1 | 7 | | |
| Grade 2 | 64 | | |
| Grade 3 | 13 | | |
| Grade 4 | 1 | | |
| b. Transitional cell carcinoma | | 7 | |
| c. Lymphoepithelioma | | 2 | |
| d. Spindle cell carcinoma | | 2 | |
| e. Schneiderian carcinoma | | 12 | |
| Grade 2 | 1 | | |
| Grade 3 | 11 | | |
| 2. Adenocarcinoma | | | 11 |
| 3. Spindle cell sarcoma | | | 2 |

Table 5. Of the 121 cases suitable for detailed histologic study, 108 were reported as having an epidermoid structure. Eleven were adenocarcinoma and two spindle cell sarcoma.

As is shown in Table 6, metastases occurred in 37 of our cases (29 per cent of the total). Undoubtedly, metastases to the lateral pharyngeal nodes are seldom recognized or even sought for. If one were able to obtain an autopsy examina-

tion in each fatal case, I am certain a fairly large percentage would show evidence of secondary deposits.

Paranasal sinus cancer usually spreads by direct extension or by one of two lymphatic pathways (see Table 7). Dissemination into the anterior lymphatics rarely takes place

TABLE 6. SUMMARY OF THE INCIDENCE OF METASTASES OF CANCER OF PARANASAL SINUSES.

| | |
|---|---|
| Total number of cases | 127 |
| Number of cases with metastases | 37 (29.2%) |
| Number of cases with metastases living without disease | 2 ( 5.4%) |
| LOCATION OF PRIMARY TUMOR — 37 CASES WITH METASTASES: | |
| Antrum | 28 |
| Ethmoid | 3 |
| Frontal | 3 |
| Two or more sinuses | 2 |
| Sphenoid | 1 |

Table 6. Paranasal sinus cancer produces metastases in 29 per cent of the cases.

TABLE 7. METASTASES OF CANCER OF PARANASAL SINUSES — LYMPHATIC PATHWAYS.

| | |
|---|---|
| PATHWAY No. 1 POSTERIOR | Rich lymphatics of antral and other paranasal sinuses.<br>Drainage backward toward choanal plexus.<br>Anastomose with branches from above and below the Eustachian tube.<br>Extend backward to nasopharynx.<br>Enter retropharyngeal space and drain into lateral pharyngeal lymph node.<br>Upward to medial jugular node to base of skull.<br>Downward to deep jugular chain — usually at bifurcation of carotid artery. |
| PATHWAY No. 2 ANTERIOR | Anteriorly through regular lymph channels of oral cavity into submaxillary and carotid bulb nodes. |

Metastasis through the lymphatics may take place along two different pathways. The more frequent course is backward and downward to the deep jugular chain. Less frequently, a secondary deposit may travel anteriorly into the submaxillary and carotid bulb nodes.

unless the cancer has penetrated into the cheek, the hard palate or into the nasal passageway.

Sometimes cancer of the paranasal sinuses metastasizes by way of the blood stream to the lungs, bones, spleen, liver and pericardium, but this manner of spread is relatively infrequent (see Table 8).

Eighteen of our patients (14 per cent) of the entire group had metastases on admission, and an additional 19 patients developed metastases during the course of their disease. Cross cervical metastases (see Table 9) occurred in five cases of cancer of the antrum, and in nine instances cancer of the antrum metastasized to the lymph nodes in the submaxillary triangle. Of the group with proven metastases, only two are living and free of disease. The advent of metastatic disease complicating the course of a patient with paranasal sinus cancer is, indeed, of grave prognostic significance.

TABLE 8. SUMMARY OF THE LOCATIONS OF METASTASES OF CANCER OF PARANASAL SINUSES.

| Location of Metastases | No. of Cases | Per Cent |
|---|---|---|
| Carotid bulb nodes | 10 | 27.0 |
| Upper neck nodes | 9 | 24.3 |
| Submaxillary nodes | 9 | 24.3 |
| Preauricular nodes | 5 | 13.5 |
| Lungs | 5 | 13.5 |
| Pleura | 3 | 8.0 |
| Bronchial nodes (mediastinal) | 2 | 5.4 |
| Abdominal nodes | 2 | 5.4 |
| Bone: Ilium | 2 | 5.4 |
| Bone: Cervical spine | 1 | 2.7 |
| Spleen | 1 | 2.7 |
| Liver | 1 | 2.7 |
| Pericardium | 1 | 2.7 |
| Axillary nodes | 1 | 2.7 |
| Supraclavicular nodes | 1 | 2.7 |

Showing that paranasal sinus cancer metastasizes widely through the blood and lymph streams.

The treatment of cervical metastases from cancer of the paranasal sinuses follows for the most part the indications which obtain for other types of intraoral cancer. These principles have been followed by our group at the Memorial Hospital for a number of years. Since they have been stated and reported (Janeway,[3] Quick,[12] Duffy[2] and Martin[5]) in the past, we may omit discussion of this controversial point in the present report. In this series of 37 cases of metastatic paranasal sinus cancer, three patients had neck dissections performed, 14 patients (38 per cent) were treated by interstitial radon in the form of gold seeds, either inserted transdermally or after surgical exposure of the tumor, seven (19 per cent) were treated by divided doses of high voltage Roentgen ray,

and three (8 per cent) received radiation with the radium element pack. Ten patients with metastatic paranasal sinus cancer did not receive any specific treatment to the secondary deposits. Several cases in this group had their metastases discovered only at autopsy. In others there were obvious liver and lung metastases and treatment was withheld for this reason. Several patients did not keep their appointments or were considered too weak to permit even palliative radiation therapy. Of the two cured cases, one had a complete

TABLE 9. SUMMARY OF METASTASES OF CANCER OF PARANASAL SINUSES.

Cancer of Antrum with Cross Cervical Metastases — Five Cases:

| Case | Pathology | Extension of Primary Lesion |
|---|---|---|
| F. F. | Squamous carcinoma, Grade 2 R. R. | Hard palate |
| A. F. | Squamous carcinoma, Grade 3, R. S. | Not stated |
| N. B. | Squamous carcinoma, Grade 2, R. R. | Nasal passage |
| A. K. | Squamous carcinoma, Grade 2, R. R. | Orbit, oral cavity, nares |
| S. B. | Not stated | Orbit, base of brain, alveolar ridge |

Cancer of Antrum with Submaxillary Node Metastases — Nine Cases:

| Case | Pathology | Extension of Primary Lesion |
|---|---|---|
| G. R. | Adenocarcinoma | Anterior alveolar ridge |
| T. S. | Adenocarcinoma | Nares |
| V. S. | Schneiderian carcinoma, R. S. | Anterior nasal passage |
| N. B. | Squamous carcinoma, Grade 2, R. R. | Nares and orbit |
| E. C. | Epidermoid carcinoma, Grade 2 | Nares |
| N. H. | Squamous carcinoma, Grade 2, R. R. | Oral cavity |
| A. K. | Squamous carcinoma, Grade 2, R. R. | Orbit, nares, hard palate, alveolar ridge |
| E. S. | Squamous carcinoma, Grade 2 | Nares |
| H. H. | Anaplastic carcinoma | Orbit, nares, oral cavity |

In each case of metastasis by the anterior lymphatic route, the primary cancer had extended into the oral or nasal cavities.

surgical removal of the metastasis, and the other was treated entirely by divided doses of Roentgen ray.

*Treatment of Paranasal Cancer:* Although the status of each particular patient determines the type of treatment selected, at the Memorial Hospital we have had no opportunity of seeing and treating the early, small, localized cancer of a paranasal sinus, which, theoretically, could be widely removed surgically with safety to the patient and reasonable assurance of ultimate tumor control. Such settings undoubt-

edly do occur but patients in this class usually have their cancers discovered by accident during operative treatment for supposed benign sinusitis.

In the present series of cases, treatment was in no instance limited to surgical measures alone. In the moderately advanced group, where complete elimination of disease might reasonably be hoped for, the plan of treatment was one of two general courses, as shown in Table 10. Plan A is based on the principle of quick radiation by interstitial radon in

TABLE 10. PROCEDURE IN THE TREATMENT OF CANCER OF THE ANTRUM.

| | |
|---|---|
| Plan A: | 1. History and physical examination. |
| | 2. Aspiration biopsy or formal biopsy. |
| | 3. Stereoscopic X-ray of sinuses. |
| | 4. Ligation of external carotid artery. |
| | 5. Insertion of gold filtered radon seeds. |
| | 6. Cautery excision of tumor-bearing area. |
| | 7. Nasal tube feedings; liver and vitamin therapy. |
| | 8. Irrigations. |
| | 9. Dental prosthesis. |
| Plan B: | 1. History and physical examination. |
| | 2. Aspiration biopsy or formal biopsy. |
| | 3. Stereoscopic X-ray of sinuses. |
| | 4. Divided doses of 200 K.V. X-ray: |
| | a. Bilateral malar or temporal portals. |
| | b. Peroral portals. |
| | 5. Conservative surgery: |
| | a. Caldwell-Luc for drainage. |
| | b. Transfusions. |
| Plan C: | 1. History and physical examination. |
| | 2. Aspiration biopsy or formal biopsy. |
| | 3. Stereoscopic X-ray of sinuses. |
| | 4. Palliative procedures aimed at growth restraint and alleviation of pain. |

The A and B plan of treatment was carried out in most cases in which the patient was suitable for aggressive therapy. The C plan was carried out in such cases as were considered too advanced for complete control.

the form of gold filtered radon seeds (see Fig. 4), followed by wide cautery excision of the tumor and its condemned surrounding bony structures (see Figs. 5 and 6). This plan of treatment was followed almost exclusively until the divided dose principle of Roentgenotherapy became popular in 1931.

In Plan B the treatment is again a combination of radiation and surgery. In this group, however, the major responsibility falls on external radiation, which is usually administered by the divided dose method. Relatively small beams of

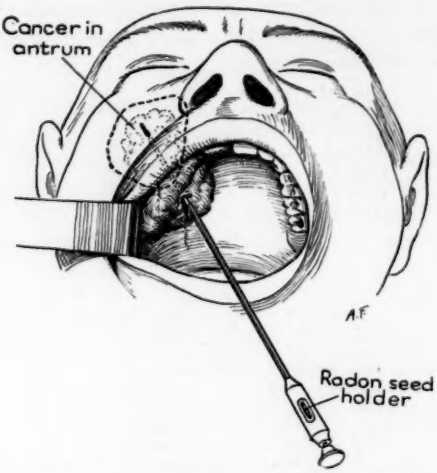



Fig. 4. Cancer of antrum, treatment. A large dose of radon, in the form of gold filtered radon seeds, is implanted directly into the center of the tumor by means of a special seed holder.

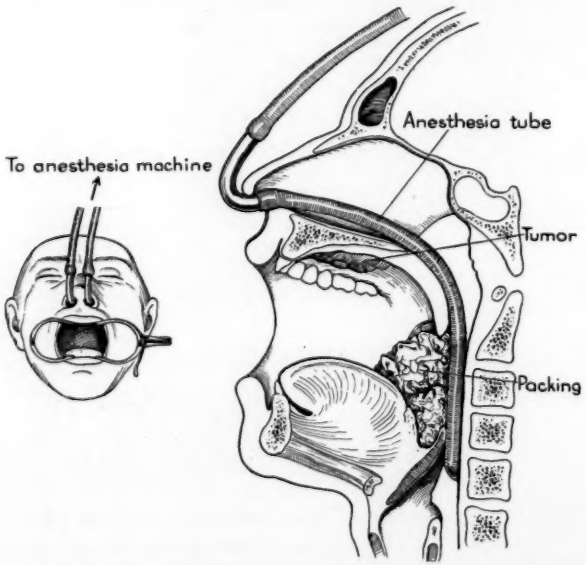



Fig. 5. Cancer of antrum, operation. Preparation of the patient and method of administering the anesthetic. Induction with $NO_2$ and oxygen, changing to chloroform at start of cautery excision.

200 K.V. are shot through the malar or temporal regions so as to converge at the tumor site. Peroral portals are added if possible, and orbital contents and tongue are protected by lead shields. Surgical procedures in this group are conservative in nature, and are utilized only when necessary for the control of hemorrhage or for the establishment of drainage for sinus empyema.

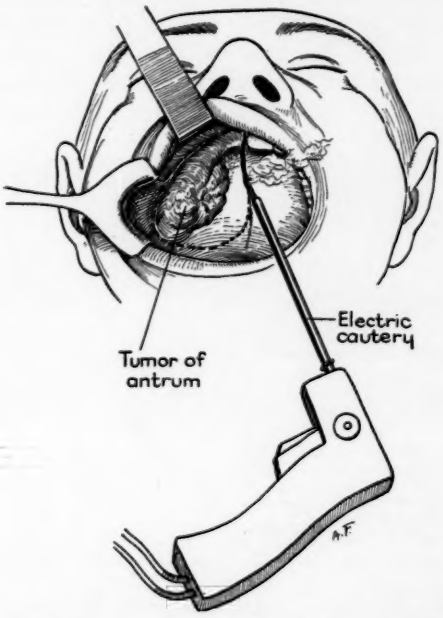



Fig. 6. Cancer of antrum, operation. Cautery removal of the antrum through the mouth. The bony walls and the floor of the orbit are removed by suitable bone instruments. The ethmoid cells are curetted.

Plan C is reserved for that group of patients with hopelessly advanced paranasal sinus cancer, in whom prolonged sepsis and pain have produced a serious state of general debility. A considerable palliative effect can be obtained if these patients are hospitalized, small doses of Roentgenotherapy administered and drainage conservatively instituted. The patient's general breakdown is attributable more often to

infection and cellulitis than to the cancerous process as such, and careful cleansing by the patient himself, with the assistance of a trained nursing staff, together with proper nourishment, and conservative incision and drainage, when indicated, will often produce unexpected and gratifying palliation.

Antrotomy for cancer of the antrum, as a step in the treatment, was carried out at the Memorial Hospital 45 times during the period between 1928-1934 without an operative death. Of this group, eight, or 17.7 per cent, are alive, without evidence of disease for at least five years (see Table 11).

TABLE 11. ANTROTOMY IN CANCER OF PARANASAL SINUSES — 1928-1934.

| | |
|---|---|
| Cases operated upon | 45 |
| Postoperative deaths | 0 |
| No evidence of disease after five years | 8 — 17.7% |

Cautery antrotomy and removal of the gross tumor was not followed by a single postoperative death in 45 consecutive operations.

TABLE 12. COMPLICATIONS OCCURRING IN CANCER OF PARANASAL SINUSES.

| | | |
|---|---|---|
| Osteoradionecrosis | | 23 |
| Cellulitis and infection | | 19 |
| Panophthalmitis requiring enucleation | | 13 |
| Cataract | Treated side 5 | |
| | Opposite side 4 | 9 |
| | Both sides 1 | |
| Hemorrhages | | 6 |
| Erysipelas | | 2 |
| Meningitis | | 1 |
| Glaucoma | | 1 |
| Loss of extraocular movements | | 1 |
| Pterygoid process fracture | | 1 |
| Perforated gastric ulcer | | 1 |
| Otitis media | | 1 |
| Amnesia | | 1 |

Osteoradionecrosis, cellulitis and infection, and panophthalmitis constitute the major complications of therapy.

Any aggressive form of treatment for paranasal sinus cancer, due to the nature of the disease and its location, will often be followed by serious complications. The most frequent complication in this series is osteoradionecrosis. Next in order comes cellulitis and infection, then panophthalmitis, cataract and hemorrhage. These complications may occur singly, but more often than not they appear in various combinations and present a particularly trying problem in the management of an elderly constitution already overtaxed by

pre-existing sepsis and pain (see Table 12). Multiple transfusions, a high caloric, high vitamin diet, including large doses of liver and iron, and vigorous oral hygienic measures are of inestimable value during this period.

After the patient has recovered and is free from disease, the attending physician is usually faced with the problem of restoring the defect resulting from the combined radiation and surgical therapy. Plastic surgery is often indicated, but has the disadvantage of requiring a prolonged wait for possible recurrence before it can be instituted. In addition, a satisfactory result may necessitate many operative steps, with prolonged hospitalization. This involves considerable expense

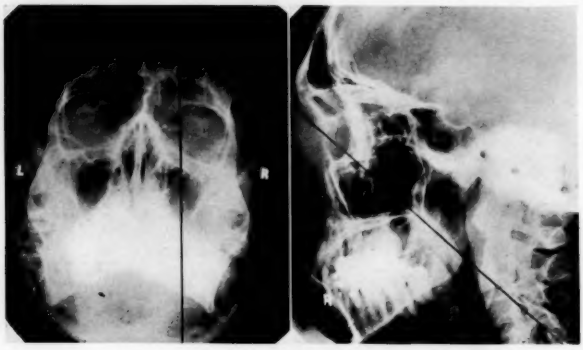
A B C

Fig. 7. Case H. P.: Cancer of antrum. (A) Shows the large defect in the cheek and the roof of the mouth. (B) Prosthetic appliance. (C) Defect closed, permitting the patient to talk and eat normally.

for the patient who is prevented from returning to a gainful occupation, and may become quite depressed. But perhaps the greatest handicap to plastic surgery is a technical one. The recipient tissues which will provide the bed for the transplants have had their blood supply altered and diminished by the previous irradiation and are, therefore, not ideal soil for this type of surgery.

A good prosthetic appliance (see Fig. 7) can be readily made with the newer rubber compounds and employed as soon as the wound is healed. The cosmetic effect is usually acceptable and the frequent removal of the appliance permits ready and thorough cleansing, as well as inspection of the defect for possible recurrent or residual disease.

*Prognosis:* In sinus cancer, three factors influence the prognosis: *1.* the location of tumor; *2.* the type of tumor and its histologic grade of malignancy; and *3.* the presence or absence of metastases. As in all malignant diseases, the size of tumor, age of patient, extent of bone invasion, general physical condition and environmental surroundings exert an influence on the prognosis. The time which elapses between the first evidence of cancer and the commencement of treatment is of great importance. The prognosis varies inversely with this time interval. In cancer of the antrum, tumor topography is especially significant, so much so that it has led




A B

Fig. 8. Malignancy planes of Ohngren. (A) A vertical plane dividing the antrum into medial and lateral halves. (B) An oblique plane passing through the inner canthi and mandibular angles to subdivide the antrum into an anterior and a posterior portion. Cancers arising in the anterior-inferior portions have a better prognosis than those arising in the posterior and superior portions of the antrum

Ohngren[10] to divide the antrum by means of "malignancy planes" into four different parts (see Fig. 8). Tumors having their origin in the anterior and inferior portions were considered to be much less malignant than those located in the posterior and superior portions. This conception seems a logical one in view of the relative ease with which tumors in the latter position can extend to the orbit and base of the brain and metastasize through the rich lymphatics by the posterior route. In practice, however, one seldom sees a patient early enough in the course of his disease to determine the site of origin accurately enough to allow practical appli-

cation of Ohngren's premise. When cancer of the paranasal sinuses has extended beyond the walls of the cavity in which it has its origin, the chances for complete control of disease are appreciably diminished.

The degree of histologic malignancy has a direct bearing on the ultimate salvage rate. Ultimately we must depend largely on radiation measures for the complete eradication of disease, and tumor radiosensitivity is, therefore, of considerable prognostic significance. Of the 15 cured cases in this series, the biopsy material was histologically graded in 13 instances. Seven were Grade 2, three were Grade 3, two were Grade 1, and one was Grade 4. Schneiderian type of paranasal sinus cancer was the diagnosis in three of the 15 cured cases, or 20 per cent, whereas in the entire series of cases, Schneiderian carcinoma comprised less than 10 per cent of the total.

The presence of metastases, either local or distant, is of grave significance in any type of head and neck cancer, and this is especially true of neoplasms having their origin in the paranasal sinuses. Here, the disease tends to remain localized until late in the course of the disease, and if metastases are present it usually indicates that the disease is far advanced and of long standing, and a five-year control of disease is unlikely.

*Survival Rate:* Ninety-four patients included in this study were treated from 1928 to 1934, and are suitable for a five-year survival analysis. Seventy-three of these cases are placed in the determinate and 21 in the indeterminate group for various reasons (see Table 13). Of the determinate group of 73 cases, 55, or 79.5 per cent, died of their cancer, and 15, or 20.5 per cent, are alive and free of disease at least five years after treatment. Of the indeterminate group, eight were patients who came to us for diagnosis or to check up on their private physicians — clinic shoppers and so forth. Four patients started treatment and then went elsewhere. Three patients were refused treatment; one had erysipelas and was sent to a City Hospital; the second patient's condition and extent of disease was such as to preclude active therapy, and he was sent to a nursing home, where he died three months later; and the third patient was insane and for this reason could not be admitted. Four patients died of other causes

free of cancer, and two patients were lost to follow-up without evidence of disease.

Detailed analyses of the 15 cases surviving more than five years are given in Table 14. In studying these statistics, it is interesting to note that every cured case during the last seven years has had Roentgenotherapy, and in six instances this form of therapy was the only treatment employed.

TABLE 13. FIVE-YEAR RESULTS IN 94 CASES OF CANCER OF PARANASAL SINUSES — 1928-1934.

| | | | |
|---|---|---|---|
| Determinate Group | Died of cancer | 55 | 73 cases |
| | Living without cancer | 15 | |
| | Lost to follow-up with cancer | 3 | |
| Indeterminate Group | Not treated | 8 | 21 cases |
| | Treatment not completed | 4 | |
| | Not suitable | 3 | |
| | Died of other causes — no cancer | 4 | |
| | Lost to follow-up — no cancer | 2 | |

DETERMINATE GROUP

| | |
|---|---|
| Died of cancer | 79.5% |
| Arrested cases of cancer | 20.5% |

Sixteen per cent of all patients with paranasal sinus cancer seen at the Memorial Hospital had their disease controlled for five years or more. Twenty point five per cent of a determinate group were "cured" of their cancer, or, at least, have had the process arrested.

## SUMMARY AND CONCLUSIONS.

*1.* A series of 127 cases of cancer of the paranasal sinuses is reported.

*2.* The antrum of Highmore was most frequently affected — 105 instances.

*3.* Males predominated — 82 to 44.

*4.* The average age was 54 years, and patients developed paranasal sinus cancer most frequently between the ages of 60 and 70 years.

*5.* Pain was the most common first symptom.

*6.* Roentgenographic examination showed bone invasion or actual destruction in 83 per cent of the 112 cases studied.

*7.* Squamous or epidermoid carcinoma was the histologic diagnosis in 108 cases.

*8.* Aspiration biopsy proved to be a valuable preoperative diagnostic measure.

TABLE 14. ANALYSES OF 15 "CURED" CASES OF CANCER OF PARANASAL SINUSES — NATURE OF TREATMENT ADMINISTERED.

| Case No. | Primary Site | Micropathology | N. E. D. (Years) | Treatment | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Radon Seeds | | Monel Ball | X-ray Therapy | Radium Pack | Cautery Antrotomy |
| | | | | Pre-Op. | Post-Op. | | | | |
| 1 | Antrum | Epidermoid Ca. Gr. 2, R. R. | 11 | | | x | | x | x |
| 2 | Antrum | Epidermoid Ca. R. S. | 10 | x | | | x | | x |
| 3 | Antrum | Schneiderian Ca. Gr. 3, R. S. | 10 | | x | x | x | x | x |
| 4 | Sphenoid Ethmoid Frontal | Schneiderian Ca. Gr. 3, R. S. | 10 | | | | | x | |
| 5 | Antrum | Squamous Ca. Gr. 2, R. R. | 8 | x | x | | | x | x |
| 6 | Antrum | Squamous Ca. Gr. 1, R. R. | 8 | | x | | x | x | x |
| 7 | Antrum | Squamous Ca. Gr. 1, R. R. | 8 | | x | | | | x |
| 8 | Antrum | Epidermoid Ca. Gr. 4, R. S. | 7 | | | | x | | |
| 9 | Frontal | Squamous Ca. | 7 | | | | x | | |
| 10 | Antrum | Squamous Ca. Gr. 2, R. R. | 7 | x | x | | x | | x |
| 11 | Antrum | Squamous Ca. Gr. 2, R. R. | 7 | | | | x | | |
| 12 | Antrum | Epidermoid Ca. Gr. 2 | 6 | | | | x | | x |
| 13 | Antrum | Squamous Ca. Gr. 2 | 5 | | | | x | | |
| 14 | Ethmoid | Schneiderian Ca. Gr. 3, R. S. | 5 | | | | x | | |
| 15 | Antrum | Squamous Ca. Gr. 2 | 5 | | | | x | | |

Analyses of 15 "cured" cases of paranasal sinus cancer showing the increased importance of modern Roentgen therapy in the treatment of the disease.

*9.* A plan of treatment is briefly outlined.

*10.* The operative steps in antrotomy for antral or ethmoid cancer are illustrated. Forty-five patients were operated upon without an operative death.

*11.* The most frequent complication was osteoradionecrosis followed closely by cellulitis and panophthalmitis.

*12.* Metastasis occurred in 37 cases, or 29 per cent of the series.

*13.* The survival rate was 20.5 per cent.

*14.* The prognosis depends largely upon three factors: *1.* Topography of the tumor. *2.* Grade of tumor malignancy. *3.* The presence or absence of metastases.

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## CONGENITAL WEBS OF THE LARYNX.*

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Congenital webs or diaphragms of the larynx are uncommon but should not be regarded as rare anomalies. Although Sir St. Clair Thomson (1916 and 1937) stated in his textbook that only 23 cases were on record, we have found in an extensive review of the literature 133 cases. The present paper summarizes and analyzes these reports with special attention to the embryologic explanation of the several variations that have been described, and reports a new case observed recently in the Otolaryngological Dispensary of the Johns Hopkins Hospital, Baltimore.

Schnitzler (1881), Hansemann (1898), Harmer (1902), Kiar (1906) and others have stated that these congenital anomalies are not very rare; however, they did not have the supporting evidence that we are now able to present.

The modern art of laryngoscopy really began in the middle of the nineteenth century with the introduction of simple and practical methods of examination by Czermak (1848). For this reason, earlier cases of laryngeal anomalies were only discovered at postmortem examination. Fleischman, in 1820, first discovered a congenital laryngeal diaphragm and other malformations at the autopsy of an infant, age 27 days. Rossi (1824) described a thick membrane at the level of the vocal cords which caused a complete atresia in a male infant who died immediately after birth. Rose (1866) also found at autopsy a congenital atresia in which the obstruction was complete from the base of the epiglottis to the trachea.

Zurhelle (1869) was the first to report a case discovered by indirect laryngoscopy. In a boy age 11 years, with hoarseness, dyspnea and inspiratory stridor dating from birth, two congenital membranes were found; one connected the anterior two-thirds of the false cords, the other the anterior three-fourths of the true cords. Elsberg's case

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(1870), the first to be reported in this country, was the second discovered by clinical examination. The more widespread use of the improved technique in the examination of the larynx soon resulted in the discovery of other cases by Mackenzie (1874), Böcker (1877), Scheff (1878), Poore (1881), DeBlois (1884), McBride (1885), Seifert and Hoffa (1888). The reports of typical cases have since appeared frequently in the literature. The fact that epithelial occlusion of the lumen of the larynx occurs normally at an early stage in its development was first observed by Roth (1878). Scheff (1878) was the first clinician to attempt to explain the cause of congenital laryngeal webs on the basis of Roth's embryological findings, and he believed that web formations are the result of arrested development.

Solis-Cohen (1881) did not believe that congenital webs occur; he thought they are due to inflammation in the fetus or in infancy. Although some believed that congenital syphilis is the cause, McBride (1885) warned that "grave injustice may be inflicted on patients by ascribing such a condition to syphilis." Poore (1881) stated that such webs are caused either *1.* by the occurrence of disease or inflammation in utero, or *2.* by the arrest of embryological development, or *3.* by the survival of some fetal condition. He believed the last to be untenable, since actual webs are never a part of the normal development. Seifert (1888) and Chiari (1897) believed in the intrauterine inflammation theory, stating that these webs are a form of "chorditis vocalis hyperplastica." This theory is no longer tenable. Hansemann (1898), however, believed that early inflammation plays a part in preventing the normal "dissolution" of the embryonic adhesions in the glottis, thus producing webs or bands. Fein (1903) was opposed to certain details of the adhesion theory. He argued that the webs do not consist solely of epithelium but "also contain mesodermal elements, *i.e.*, muscle, glands and cartilage," and concluded that the condition is due to an excessive growth of mesoderm. Glas (1908) objected to Fein's theory, for he believed that the malformation is due primarily to epithelial fusion, with secondarily a growth of mesoderm into (*i.e.*, between the layers of) the epithelial mass. Frankenberger (1905) and Krosz (1914) accepted Fein's theory, whereas Weingaertner (1920) was of the opinion that proof of either cannot be demonstrated. Calderin

(1922) believed as a result of his experiments on frogs that "congenital anomalies" are due to endocrine disturbances in the embryonic state causing delayed development.

For a better understanding of the development of the cavity of the larynx and the etiology of these congenital webs, we will briefly summarize the accepted embryology according to the investigations of Roth (1878), Kallius (1897) and Frazer (1910). In the human embryo, the branchial arches differentiate from before backwards, and by the third week the first and second arches are easily distinguishable, while the third is indicated laterally. The pulmonary outgrowth takes place at this time, when the fourth arches are not yet apparent. Then the central longitudinal prominence (Frazer), or central mass (Kallius), is formed from the third and fourth arches and lies in front of the opening of the outgrowth. The fifth arches, in the floor of the pharynx, run parallel along either side of the opening, and by the beginning of the fourth week the pulmonary ougrowth has increased in length caudally so much that only its pharyngeal or cephalic end is held, as it were, between the fifth arches.

The proximal part of the outgrowth thus included becomes the lower part of the cavity of the larynx, and the remaining upper part of the cavity is added to this secondarily (according to Frazer). The condensed mesenchyme that forms the basis of the fifth-arch mass is very distinct in its limit in the 5 mm. embryo, and as the masses grow, the proximal opening of the pulmonary outgrowth is compressed between them and the epithelial lining of the walls becomes adherent, thus converting the cephalic opening of the outgrowth into a sagittal cleft. The occlusion is complete except for a small dorsal channel which runs downwards and backwards from the hinder end of the cleft into the "trachea." This may or may not be patent. A small anterior channel may also be present (see Fig. 1A).

The masses of the fourth and of the fifth arches continue to increase in size and about the end of the first month blend together to form a common lateral mass (arytenoid swelling — Kallius) on each side of the cleft. The lateral mass thus formed grows forward, folding itself over the central mass (epiglottic ridge — Kallius), so that a secondary transverse cavity is built up, opening between the lateral masses into the

original sagittal cleft (see Fig. 1D). After this the rapidly developing cartilages in the fifth-arch mass form a supporting framework that holds the mass as a whole in the position it has gained.

The general "epithelial adhesion" in the sagittal cleft begins its "dissolution" from below with the formation of the cri-

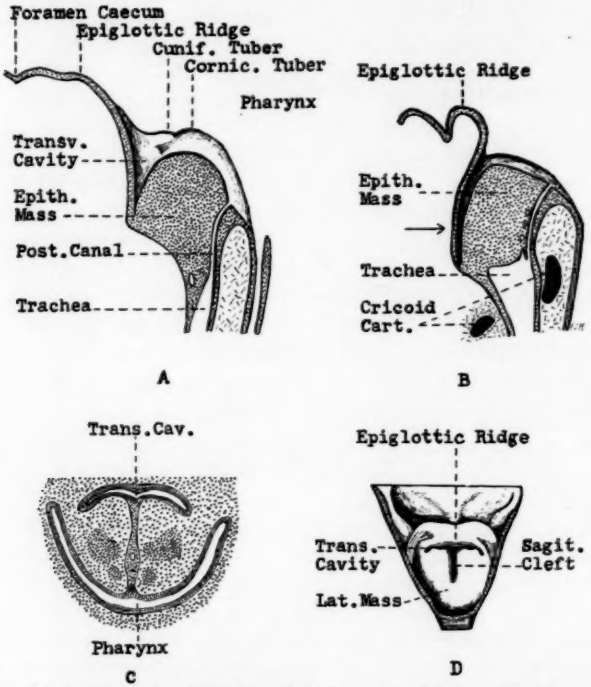


Fig. 1. Drawings to show the critical stages of the embryology of the human larynx (after Kallius). (A) Sagittal section at 28 to 29 days. x 50. (B) Sagittal section at 40 to 42 days. (C) Horizontal section at level indicated in (B). Note in central fused region of the sagittal cleft the opening of the posterior canal. The heavier condensations on each side of the fused area are the future arytenoid cartilages. (D) The entrance to the larynx at 40 to 42 days seen from above and behind. x 15.

coid cartilage, and from above and in front with the "settling down" of the dorsal part of the fifth-arch mass on the forming arytenoid (see Fig. 1C). Normally the "dissolution" is complete by the end of the second or the beginning of the third month (Kallius and Frazer). The true cords are developments in the bridge of continuity that exists between the

ventral and dorsal parts of each fifth-arch mass. Each cord is preceded by the appearance of a "chordal nodule" (Frazer) whose subsequent differentiation (or "atrophy" — Frazer) leaves it attached to the thyroid junction, and as growth continues it is drawn out as a strand of cells connecting it with the arytenoid. The ventricular folds, or false cords, appear at the same time as the true vocal cords. The ventricles are outgrowths from the transverse cavity, occurring about the eighth week, just above the vocal cords. When complete or partial occlusion occurs, it is the result of incomplete separation of the fusion process and there remains a base of mesoderm covered with epithelium.

Congenital webs, diaphragms, adhesions or bands occur most commonly at the level of the vocal cords but may be subglottic or supraglottic. Double webs have also been observed; the first case reported (Zurhelle) was of this type. The atresic or imperforate forms are less commonly reported. Although only seven cases were found in this review, we agree with Kiar, Hansemann and many others who believe that they are more common. It is quite conceivable that they could be missed at autopsy because of the technique of splitting open the larynx in the midline anteriorly. Also because it is not a universal practice to autopsy all infants dying immediately or shortly after birth, many more cases must surely be missed. Hansemann said that he saw "many cases" at autopsy in an obstetrical department.

Other congenital deformities occur in these patients with laryngeal anomalies. In this review of 133 cases we found 15, or 11.3 per cent, associated with other malformations. Ross (1901) stated that "arrested development of the larynx is sometimes found along with imperfection of the genital tract, and the respiratory apparatus being formed from the same source as the larynx, it is rare to find that organ maldeveloped without some want of complete formation in the lungs, trachea or bronchi." His case, a female, age 3 years, had a large laryngeal web and was otherwise normal. In no case in this series was there any evidence of coexisting anomalies in the trachea, bronchi or lungs; however, Schröder (1931) reported the case of an infant who died at 11 weeks of age as the result of a bronchopneumonia and an almost complete congenital atresia of the larynx; at autopsy he con-

firmed the laryngeal findings and also discovered a stenosis of the right ureter. Imhofer (1911) advised that coexisting anomalies of the eyes, palate and ears should be kept in mind. His case, a male, age 21 years, presented, in addition to the laryngeal web, a "rudimentary third eyelid" or nictitating membrane. Semon (1898) reported a girl, age 16 years, who also had a congenital coloboma of the left eye, and Fraenckel's patient (1902) had a ptosis of both eyelids since birth. This patient's mother and sister also had congenital ptosis of the eyelids. Franchi's (1908) case had a bifid uvula and soft palate. Other interesting anomalies that were found in addition to the typical laryngeal web were imperforate anus (Sieg, 1922) and webbing of the second and third toes of both feet (Powers, 1917). This latter condition was common in the patient's maternal family tree. Ferreri's case had a double mammary gland on the right side, and Frankenberger's case, a talipomanus on the right side. Glas' patient had an adherent lingual frenulum, which was also present in other members of the same family. Multiple anomalies are more common with the complete atresic or imperforate type of larynx, since in these 15 cases other gross anomalies were found in six associated with the imperforate laryngeal form.

Hereditary influence seems to play a part and has been considered by some as an etiological factor. Seifert, Glas, Fraenckel, Schmidt, Meyer and Clerf reported finding congenital webs in other members of six families, or 4.5 per cent of these cases (Glas had two families). Seifert examined the family of his case and found the father and one sister had very small webs in the anterior commissure, and another sister had the anterior half of her vocal cords united by a typical web or diaphgram. The mother of Fraenckel's patient (male, age 22 years) had a tiny web in the anterior commissure; Seifert and many others agree that this condition is common. Glas reported that the mother of his first patient had a "congenital adhesion" in the anterior part of the vocal cords, while the father and two sisters of his second patient (female, age 30 years, with a web uniting the anterior one-fourth) had a "similar formation." Schmidt and Meyer saw a brother and sister who had similar laryngeal webs, and Clerf (1931) reported two cases who were brother and sister. Only 11 other authors stated whether the families of their patients were normal, some few were actually examined, others gave

"no history of a similar affection"; however, a negative history is of no value; the webs may be small and cause no serious symptoms. Heredity is probably a more important factor than we can say from this series of cases because so few families were actually examined. It may be significant that in the 16 families reported to have been examined, six, or 37 per cent, showed positive evidence of similar laryngeal anomalies.

As shown above in Figs. 1A, 1B and 2, congenital webs of the larynx may occur as a result of arrested development at any level in the whole region of the early epithelial occlusion; *i.e.*, at, above or below the vocal cords. Single webs are

Fig. 2. A sagittal section of an adult human larynx showing the region in which congenital webs occur.

by far the most common, but Zurhelle, Rosenberg and Nakayama reported double webs.

*Site:* Of these 133 cases, 100, or 75.2 per cent, were at the level of the vocal cords; 10, or 7.5 per cent, were subglottic; two, or 1.5 per cent, were supraglottic; five, or 3.7 per cent, were found in the posterior wall of the laryngeal cavity, mainly in the interarytenoid region; and seven cases, or 5.26 per cent, presented complete atresia. The exact site was not mentioned in nine cases. Four cases showed actual adhesion of the anterior portions of the cords (Himmelreicher, Clerk, Lange). Tucker's case (1935) showed adhesion of the ante-

rior one-third and a web in the middle third. These cases are correctly included in this series. From these figures we can see that subglottic webs are rather rare, and single supraglottic webs are extremely rare. The small webs occurring in the posterior wall are believed by many to be much more common than the above figures would indicate. They are probably disregarded by most observers as they cause few or no symptoms, and, as has been mentioned above, the imperforate forms are probably more common.

*Size:* The webs may vary in size from a rounded anterior commissure to a complete atresia. In order of frequency (in 108 cases) they involve at the level of vocal cords the anterior two-thirds, one-half, one-third, one-fourth, three-fourths and four-fifths, or they may only present a tiny posterior opening large enough to admit "a quill" (Böcker, 1877) or "a knitting needle." Clerf's second case had a small posterior opening, 1.5 mm. in size. Although in this series the same number (seven) involved the anterior commissure (Seifert's cases) as those uniting the anterior one-fourth, almost every modern laryngologist agrees that this form (in the anterior commissure) is very common; so common that the cases are not worth reporting. It is surprising how long an infant can live with an inadequate airway. Schmiegelow discovered in an infant that died at 5 weeks of age a subglottic diaphragm, the posterior opening in which permitted only the passage of "a tiny probe."

*Shape:* These webs are wedge-shaped, the upper surface (on inspiration) is flat, smooth and stretched in appearance. The posterior border is thin (only one was thick in this series), sharp, regular and concave, while the under surface is concave downwards, since the part occupying the anterior commissure is always much thicker; it may be 8, 10, 12 (Krosz) and even 15 mm. (Semon) thick.

*Histology:* The upper surface is usually smooth and covered with squamous epithelium, which may be normal in appearance but is often "over-grown" and sometimes "hornified" (Chiari). Below this is a varying amount of connective tissue containing blood vessels around which may occasionally be found a small round-cell infiltration; however, this is not evidence in favor of the inflammation theory of origin. The under surface is covered with normal mucous membrane. In

the thicker anterior portion, and especially below the anterior commissure, there is a great increase in the amount of fibrous connective tissue which is more dense and contains also mucous glands, striated muscle fibres and occasionally cartilage and fat (Schröder, 1931). In a few cases, notably Mackenzie's, there were definite histologic "papillomatous" appearances on the upper surface of the web. Hopmann had a case with a congenital web in the anterior commissure in addition to multiple papillomata in a female, age 30 years. Brunetti (1937) and Ferreri and Cipollona (1923) also reported cases with congenital webs in addition to the presence of small papillomata on the free parts of the vocal cords. With the exception of Mackenzie's case which showed the histologic papillomatous changes in the web, the findings in the other cases may have been purely coincidental, or the presence of the webs, resulting in interference with the normal function of the cords, may have played a part in the production of the papillomata; however, this is purely conjectural, and we merely mention these cases because they are unusual.

*Color:* These webs are usually grayish-white and glistening, but may be grayish-yellow or pinkish and, in a few cases, hyperemic. One must remember that they may be discovered at a time when the patient is suffering from an acute upper respiratory infection. These webs are usually found in adults quite accidentally in routine examinations, but some patients complained of severe hoarseness and dyspnea as a result of a superimposed infection. Sometimes the central and posterior portions of the web may be so thin as to appear translucent (Semon and Mazoub). The webs, on the other hand, may be very dense and white (Franklin). Blood vessels may be clearly visible near the surface, or may be absent to the naked eye. The thin posterior edge has led many to believe that it would be a simple procedure to remove the web, and many of the early attempts at treatment failed because the operators did not realize that the anterior portion is very much thicker and readhesion is a common postoperative result.

*Position:* On inspiration, the webs present the typical flat appearance, with the sharp concave posterior border. On phonation the web may fold above or below the cords, and in a very few cases it wrinkled upon itself so as to remain

between the cords, but this is a rare finding. Jackson (1915) observed a case in which the web folded above the cords and was mistaken at first for an irregular tumor, but on inspiration presented the typical appearance of a web. When the webs fold below the cords they may pass completely out of sight, with very little interference in the adduction of the cords, but perfect adduction is not possible. Any interference with adduction will naturally lead to hoarseness. Due to the thickness of the anterior commissure in small webs, the movements of the cords may be impaired to a surprising degree. The subglottic, supraglottic and posterior webs usually move up and down on inspiration and expiration.

*Sex:* Congenital laryngeal webs have been found more frequently in females. In this series there were 57 females, or 43 per cent, 46 males, or 34.5 per cent, and the sex was not stated in 30 reports, or 22.5 per cent. The last figure, however, is so great that we will not attempt to account for the apparent predominance in females.

*Age Distribution:* Congenital webs of the larynx have been discovered so frequently at all ages that it is of clinical importance to remember that hoarseness and dyspnea, even in adults, may be due to congenital webs in the glottis. The youngest patient was a premature infant (age 8 months) and the oldest was an adult (sex not stated) of 70 years (Krymon, 1928). The chart below shows that 59, or 44.6 per cent, of these cases were discovered between the ages of 11 and 30 years. The webs occurring in older patients were usually found accidentally. In these groups, the stated age is the time at which the web was discovered.

| | |
|---|---|
| 0- 1 years | 23 |
| 2-10 years | 14 |
| 11-20 years | 29 |
| 21-30 years | 30 |
| 31-40 years | 6 |
| 41-50 years | 4 |
| 51-60 years | 1 |
| 61-70 years | 3 |
| Not mentioned | 23 |
| Total | 133 |

*Symptoms:* The great majority of these patients were reported to have been in otherwise good health, a few were weak, "poorly developed and anemic" (Elsberg). A large num-

ber were subject to frequent colds (v. Eicken), associated with which their symptoms were greatly aggravated (Fraenckel, Lehm). The symptoms produced in each case, of course, depend upon the size and position of the web. The tiny anterior commissure webs or adhesions may cause no symptoms or only slight and intermittent hoarseness. The larger webs at the level of the vocal cords usually result in: *1.* hoarseness, or attacks of aphonia; *2.* attacks of dyspnea, more marked on exertion or excitement and frequently severe with colds; *3.* the voice may be weak and high-pitched (Kriegsman), falsetto (MacDonald and Poore) or toneless; *4.* the "voice tires easily" is a common complaint (Glas, Hansberg, Schiffers), especially in such occupations as teachers and singers, etc. The voice can seldom be reinforced by energetic effort. Vertigo and palpitation with strenuous exercise (Franchi) is a less common complaint. In infancy, other symptoms are more prominent; the commonest are: *1.* inability to cry "properly," or aphonia; *2.* inspiratory and expiratory stridor, which may be "crowing" in character (Jackson); *3.* difficulty in feeding is a fairly common finding, due to air hunger (Hansberg, Guthrie and Schröder); *4.* attacks of severe dyspnea, cyanosis and suffocation (Kriegsman) with suprasternal and intercostal indrawing on inspiration, which may demand urgent treatment; *5.* actual "convulsions" have occurred (Hodge and Gibb), and "coma" was reported in one case (Gibb). The patients usually learn to talk late (Kraus) (Ross' patient was voiceless for three years), and the voice may remain puerile into adult life (DeBlois and New). In some cases the voice "improved" with the growth of the larynx (Semon); the "improvement" was often noticed about puberty, but the change was only temporary, and in no case was it permanent. Mackenzie's patient remained voiceless until the age of 21 years, when the web was removed by punch forceps, immediately following which the patient spoke for the first time.

The symptoms associated with subglottic webs are different. There is seldom any change in the voice and the common complaints are: *1.* severe attacks of dyspnea, simulating asthma, or *2.* constant dyspnea, and *3.* "croupy cough." For the sake of completeness, we may add that some cases were reported to have had associated with the laryngeal anomaly

atrophic rhinitis and pharyngitis (Imhofer, Calderin, Ferreri and Cipollona).

*Diagnosis and Differential Diagnosis:* The diagnosis of congenital laryngeal webs can usually be made in adults by indirect laryngoscopy, but occasionally the direct method may be necessary, as with infants and young children. Webs of the larynx may be: *1.* congenital, or *2.* acquired. The congenital type has been fully described above. The acquired forms may be the result of infections or trauma.

*Infectious Causes:* Webs have occurred in the larynx as the result of diphtheria, typhoid, scarlet fever, tuberculosis, syphilis (during the tertiary stage — Hill —or developing in the course of treatment of a local laryngeal lesion — Gorman), spotted fever, leprosy, rhinoscleroma, lupus, glanders, pemphigus (Lipschütz), kala azar, soor or thrust (Sternberg) and any form of perichondritis.

*Traumatic Causes:* These have been observed following: *1.* intubation and high tracheotomy in children (Kiar); *2.* the removal of papillomata (McBride-Gottstein); *3.* gunshot wounds of the larynx (Milligan and O'Malley); *4.* attempted suicide, "cut throat" (Semon) or sword wounds; *5.* fractures of the thyroid cartilage; and *6.* caustics (Hodge). It is usually not difficult to differentiate the congenital from the acquired forms on examination. The congenital webs are symmetrical, with a smooth, flat upper surface, sharp concave posterior border, and are wedge-shaped, with an inferior surface concave downwards. The vocal cords are freely movable and can be abducted to their fullest extent without losing their symmetry (Kiar). Blood vessels upon the surface cannot be regarded as a differential point. The appearance of the neighboring structures is of extreme importance in the differential diagnosis. In the congenital forms the larynx is otherwise perfectly normal in appearance, whereas in the acquired form there is always evidence of scarring elsewhere, the webs are rarely, if ever, symmetrical and are irregular and dense. In conjunction with the appearance of the webs and neighboring parts of the larynx, a history of hoarseness since birth or a positive statement to the effect that the symptoms appeared after one of the above infections, or following trauma, is naturally of importance. A careful consideration of all the available facts will usually permit definite differ-

entiation between congenital and acquired forms; however, we agree that occasionally an absolutely definite diagnosis is not possible.

*Treatment:* The treatment of congenital laryngeal webs, as of cicatricial webs, is a perplexing problem, and the results are very frequently unsatisfactory and disappointing. As a result of our study of these 133 cases, we agree with the more recent observers that serious interference with respiration is the only indication for surgical intervention. Hoarseness and other disturbances of the voice do not show any appreciable permanent improvement following operations and should never be considered as an indication for treatment. The treatment consists of incision or excision with dilatation. Numerous methods have been suggested, but, in spite of the ingenuity of some, the results for the most part have been disappointing. The early surgeons attempted excision with various types and designs of punch or cutting forceps, and often used the galvanocautery knife or wire. Killian suggested laryngofissure and tracheotomy followed by dilatation with a rubber tube in place. Michelowitz and Hinsberg used glass T-shaped tubes also after excision. Beck and Smiegeloff recommended these methods. Schröder, Thost, O'Dwyer, Jackson, Tucker and many others have used dilatation, bouginage or intubation with many forms of laryngeal tubes, sometimes alone and sometimes following other procedures. Negus, Arbuckle and Figi tried to solve the problem in a different manner and used Thiersch grafts following excision. For simple congenital webs, Jackson suggested incision along one cord, thereby permitting the epithelization of the denuded cord. Iglauer suggested a novel form of treatment. A promising method is described by Haslinger, who, following excision, placed a silver plate vertically between the vocal cords in the anterior commissure. This is held in place by a wire threaded through the thyroid cartilage. He presented three cases which had been under observation from three to six months following operation. The results were encouraging, and the method is worthy of consideration. Whatever the method of treatment may be, the utmost conservatism is called for in children because the lumen grows larger as the child grows (Jackson).

*Case Report:* R. F. (J. H. H., No. K37568), negro male, age 30 years, seen Feb. 27, 1940. Complaints: *1.* sore throat,

substernal pain and "night sweats," two weeks' duration; *2.* dyspnea on moderate exertion since infancy; *3.* hoarseness "since birth." The mother states that immediately after birth it was noted that "he did not cry properly"; "he cried like a kitten." His voice has never changed; it is weak, high-pitched, rough and puerile in character. Since infancy he has had frequent severe "colds," associated with which he has had marked respiratory distress and "attacks" of cyanosis. His health has been otherwise satisfactory. He had measles, but no history of diphtheria, scarlet fever, typhoid fever, whooping cough, chicken pox, nor any local laryngeal disease. The patient has a positive Wassermann; he received weekly treatments for G. C. urethritis and syphilis for two months in 1926. There is no history nor evidence of a luetic laryngeal lesion. Physical examination revealed a well developed, mus-

Fig. 3. Drawing of the congenital web seen by the authors.

cular adult male. Eyes, ears, nose: negative. Numerous carious teeth. Tonsils small, embedded and inflamed. Anterior pillars hyperemic. Pharynx granular. Small inflamed adenoid mass. Sinuses clear. Examination of the larynx reveals a grayish-white, glistening web occupying approximately the anterior two-thirds of the vocal cords. On inspiration, the upper surface of the web is flat and a few tiny blood vessels are visible, especially in the posterior portion. The posterior border is thin, sharp, regular and concave. The cords can be completely abducted (see Fig. 3). On phonation the web folds below the vocal cords, which cannot be completely adducted. The mucosa of the larynx is normal in appearance. There is no evidence of scarring or previous inflammation in or about the larynx.

There were no other positive physical findings nor any evidence of other congenital abnormalities.

The family history is irrelevant, except that one brother died immediately after birth, "cause unknown." No history of familial disease. The parents' blood Wassermann was negative (May, 1940), and on examination no definite abnormalities of the larynx were seen. The other members of the family were not available for examination.

Although the patient has a positive Wassermann, there is no evidence of an active or healed laryngeal lesion. Considering these facts, in addition to the positive history of symptoms dating from birth, we believe we are justified in regarding this case as congenital in origin.

No treatment was advised. The patient is to return for observation.

## SUMMARY.

Although congenital webs or diaphragms of the larynx have usually been regarded as rare anomalies, 133 cases were found in an extensive review of the literature. These reports have been summarized and analyzed with special attention to the embryologic explanation of the several variations which do occur. A new case, discovered in the Otolaryngology Dispensary of the Johns Hopkins Hospital, Baltimore, is reported (the first to be found in a negro).

It is of clinical importance to remember that hoarseness and dyspnea, even in adults, may be due to congenital laryngeal webs. Fifty-nine, or 44.6 per cent, of these cases were discovered between the ages of 11 and 30 years.

Coexisting congenital anomalies, hereditary influence, sex and age distribution, diagnosis, differential diagnosis and treatment are fully discussed, in addition to a detailed description of the appearance and position of the various types of congenital webs which have been discovered.

Congenital webs, bands, adhesions or diaphragms of the larynx are uncommon, but should not be regarded as rare anomalies.

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# COUGH.

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Cough is a co-ordinated act designed to engage a maximum quantity of air within the lungs under high pressure, to release it suddenly and expel it rapidly.

The initiation of cough may be: *a.* entirely reflex; *b.* entirely volitional; *c.* conditioned by experience; *d.* a mixture of any two or all three of the above influences. As a corollary to this multiple control, it must be added that a cough, once initiated, may be volitionally increased or decreased in its force or duration. The principal sources of origin for reflex stimuli to cough are: the laryngeal vestibule, the tracheobronchial mucous membrane, the pleura and the diaphragm. Clerf[1] in a study of the causes of cough, in patients free from pulmonary disease, points out that cough may also arise from causes to be found in the ear, esophagus and neck.

In order that cough should be effective, it is essential that the act should receive contributions from the following parts in the order given: *a.* inspiration; *b.* closure of glottis; *c.* descent and fixation of thoracic wall; *d.* opening of glottis; *e.* plunger-like rise of diaphragm. It is understood that the 500 cc. of tidal air used by the average individual in quiet respiration is placed between an approximate 1,500 cc. of complemental air on one side and an equal amount of supplemental air on the other. In consequence, regardless of the point in the respiratory cycle at which a stimulus to cough arrives, the lungs are still capable of taking in a minimum of 1,500 cc. of air, or a maximum of 2,000 cc. of air. If the stimulus to cough is severe enough, this inspiratory movement may be interrupted at any time, but it always starts and is generally completed. A minimum of 1,500 cc. and a maximum of 3,500 cc. of air is now ready for expulsion. As soon as this movement is terminated the larynx is closed. Descent of the chest wall begins immediately and continues until an elevation of the intrathoracic pressure corresponding to the severity of the cough stimulus is reached. The larynx is then opened and the diaphragm is driven upward within

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the contracting thoracic parietes like the plunger of a great syringe. The tone of the diaphragmatic muscle, as pointed out by Coryllos,[2] acts as a physiological antagonist to the force exerted by the combined action of the abdominal muscles. In this way, the diaphragm acts as a balance and — I quote from Coryllos — "regulates the efficiency of cough with the greatest saving of time and energy during its expulsive phase."

It is not difficult to appreciate the fact that the speed and distance of the movements of air in different parts of the respiratory apparatus vary greatly. At the beginning of the expulsatory effort, the air in the extreme periphery of the lung moves at a speed and through a distance exactly equal to the speed and distance of the movements of the chest wall. The air within the trachea, on the contrary, remains stationary, except for the disturbance incident to the compression to which it is subjected. With the simultaneous opening of the glottis and rise of the diaphragm, these conditions are immediately reversed. The intratracheal air rushes rapidly outward, while the speed of air currents in other parts of the lung varies inversely as the distance from the larynx, until the periphery of the lung is reached, where movement, if it occurs at all, is very slight, except in that part of the lung immediately adjacent to the diaphragm. Rohrer[3] in his investigations estimated the speed of movement in the airways during cough as from 0.5-2 metres in the bronchiole, and from 50-120 metres at the glottis.

The value of cough in expelling the content of the tracheobronchial tree begins with the opening of the glottis. It is, therefore, apparent that its effectiveness decreases as we retreat from the larynx toward the periphery, and is entirely worthless for this purpose when we arrive at the outer fringes of the lung.

The pressure within the bronchial tubes is the result of the descent of the chest wall and rise of diaphragm. It is, therefore, also apparent that the intrabronchial pressure is dependent upon the extrabronchial pressure for its existence. If the glottis should remain closed throughout cough, the two pressures are balanced, but it is impossible under any circumstance in the anatomically normal bronchus for the intra-

bronchial to exceed the extrabronchial pressure. Cough is, therefore, not an etiological factor in dilatation of the bronchi in bronchiectasis.

This belief is now accepted by most authorities. Coryllos,[4] however, in his recent discussion of the subject draws the opposite conclusion. He treats throughout with the pathological bronchus and begins with the assumption that there is a narrowing at some point in the lumen. In other words, he deals from the beginning with a bronchus in which ectasia already exists. The conclusion demanded from his premises is that cough tends to increase bronchial dilatation where it already exists, but his conclusion that it applies to the normal bronchus is not logical.

It is, then, no longer possible to understand pulmonary drainage in terms of cough. In fact, we must seek further if we wish to understand why cough has any part whatever in pulmonary drainage. The bronchoscope has given us the answer to this problem by making it possible not only to watch the mechanism of pulmonary drainage in actual operation but also to visualize the pathological effect when any part of it is temporarily or permanently out of order. There are three components to drainage of the lung, and each of them must function normally if any of them are to be efficient. The author[5,6] has already compared their combined action to the "endless chain" method of removing dirt or snow from the streets. The material is, first of all, collected at selected points in mass or quantity. It is then delivered by an endless chain to a truck, which in turn hauls it away. In the lung, foreign material is delivered in quantity to the small bronchioles by the squeezing or pumping action of the respiratory movements[7] combined, in some opinions, with bronchiolar peristalsis. From this point it is carried upward by the action of the ciliated epithelium of the bronchial mucous membrane. At length it reaches a point where the currents of air from the bronchioles combined in the small bronchi have attained sufficient force to carry it onward. Cough then enters the scene as the truck which delivers these accumulations to the outside world, by way of the trachea, in large loads.

Pulmonary drainage is thus seen to be more complicated than it was conceived to be in the past, for it is apparent that

the whole system is vitiated by the failure of any one of its parts. It is, however, so efficient that the second division bronchi are found under normal circumstances to be sterile.

Chevalier Jackson[8] says that cough is the "watch dog" of the lungs. The use of the term "watch dog" is particularly apt in its application to cough, for a "watch dog" serves to protect his master from external aggression. But a "watch dog," even though he sleep at the gate, must, in fact, sleep as well as his master. And it is this sleep of the "watch dog" of the lungs which must "give us pause" if we are to understand the most common invasion of the pulmonary field. This invasion takes place by way of the mouth, which is, surgically speaking, the dirtiest cavity in the human body.

It is not uncommon for a patient to present himself in the doctor's office with the statement that during the night a dental bridge disappeared from his mouth and he would like to know whether he could have "swallowed" it. Although the patient may protest that he was not seriously disturbed by cough and did not miss the teeth until morning, an X-ray shows the foreign body lodged in one of the second or third division bronchi.

We have already observed that the first part of the response to a cough stimulus is the inspiration of from 1,500 to 2,000 cc. of air. This is sufficient to carry even a heavy foreign body rapidly into the trachea and deeply into the lungs. A property of the respiratory mucous membrane is that, while it is very intolerant to a foreign body in motion, it is very tolerant to a foreign body at rest. If, therefore, the foreign body should be of such shape and dimension as to fit snugly into a branch bronchus without producing obstruction, its entire transference from the mouth to its final resting place in the lung need not occupy more than a second or two. All this occurs during a time when the "watch dog" of the lungs is asleep and before the cough reflex has had time to recover its normal threshold of physiological activity, the entire episode has passed, practically without symptoms. The writer has seen this incident take place in at least two cases where a bridgework covering the space of seven teeth was involved. Knowing that such large intruders are able to find their way into the lungs with so little difficulty, it is more

easy to appreciate the myriads of organisms of every variety which may enter the trachea from infected sinuses, teeth and tonsils and putrefying food particles in the mouth.

Before leaving the realm of normality in pulmonary drainage, it is important to note that the respiratory system is the only one which works against the special handicap of always draining uphill. The human species is the only one in the animal kingdom where this is particularly true. It is interesting to note, at the same time, that bronchiectasis is a disease unique with the human species.

With this background for the mechanism of cough, under normal conditions, we are better able to understand the abnormalities which influence pulmonary drainage and produce clinical symptoms. These factors may be analyzed upon the basis of their influence upon the three parts of the mechanism of pulmonary drainage described above. There are, first, conditions producing a limitation of respiratory movement; second, conditions inhibiting the action of the ciliated epithelium; third, conditions hindering the effectiveness of cough. The factors included in these three fields are so numerous that it is impossible to undertake a complete discussion. The principal elements, however, may be outlined under the above headings.

*Conditions Producing a Limitation of Respiratory Movement:*

Respiratory movement may be limited either physiologically or mechanically. Physiological limitation is brought about by pain due to any cause; pleurisy, fractured rib or trauma (such as an operative wound). It is also produced by lesions within the lung requiring rest, such as tuberculosis or pneumonia. Mechanical limitation of respiratory movement is produced by fibrosis of the lung, adhesive pleuritis, fusion of the costovertebral articulations and the different forms of paralysis affecting the respiratory muscles (hemiplegia, poliomyelitis and phrenic nerve interruption). The effect of these conditions is to eliminate, wholly or in part, the action of the "tussive squeeze" in delivering contained mucus from the lung parenchyma to the small bronchi. This is an important barrier in the way of pulmonary drainage,

since the tussive squeeze is the first and most important part of the drainage mechanism.

*Conditions Inhibiting the Action of the Ciliated Epithelium:*

There are two factors principally concerned — the character of the content of the bronchial tree and changes within the epithelium itself or the bronchial wall. The viscidity of the mucus may be such that it clings tenaciously to the bronchial wall. This is particularly true in asthma and in the presence of organisms of the mucosus capsulatus group. It is also found in the bronchial tubes of chronic coughers. Here, due to the fatigue of the submucous glands, their product becomes diminished in amount and thicker and more sticky than normal. The entire lumen of the bronchial tubes is frequently "painted" with this material. On direct examination the mucosa seen through this false membrane appears of a pale, milky pink color. If the instrument is passed down and then retracted it will be seen that contact with the bronchial wall has "peeled" this layer away, revealing a chronically thickened and reddened epithelium underneath. Such an epithelium, hampered as it is both by inflammatory swelling and a viscous restraining membrane, cannot be expected to produce any effective ciliary action. Such a situation is undoubtedly the principal predisposing factor in postoperative atelectasis. With the effectiveness of this element in pulmonary drainage so much reduced, the additional loss of respiratory movement, due to pain, leads inevitably to bronchial obstruction, without any increase in the output or viscidity of the bronchial content. In fact, the old term, "ether pneumonia," was based upon an entire misconception, since the increased quantity and fluidity of mucus, due to the irritation of ether, would be an aid rather than a handicap to drainage in normal bronchi.

*Conditions Hindering the Effectiveness of Cough:*

The abnormalities diagnosed under the two previous headings prevent the effectiveness of cough, since this, the third part of the mechanism of pulmonary drainage, must be nullified without the contribution of the tussive squeeze and ciliary movement. Archibald[9] was the first to point out that, "whereas the usual action of cough is to expel material from

the tracheobronchial tree, it may, under certain conditions, actually bring about the opposite result; that is, drive material deeper." The "conditions" at that time (1928) were not very well understood. Carlson[10] and his co-workers confirmed these findings, emphasizing a fact that had previously been disputed, *viz.*, the bad effect of hemidiaphragmatic paralysis on cough. In their studies, as in those of Archibald, however, X-ray proof that opaque material may be forced outward into the small bronchi fails to explain *why* it happens. The explanation is found in bronchoscopic studies in which the actual mechanism can be investigated by direct observation.

Assuming that the tussive squeeze and ciliary action have delivered a mucus obstruction to one of the larger branch bronchi, it still may present many difficulties before it can be removed by cough. A primary requisite of effective cough is to have an adequate quantity of air moving at sufficient speed from a point distal to the obstructing mass. Secondary factors, as we have seen, may reduce both the quantity and speed of air delivered from a given segment of the lung. The most important of these is pain, and this is particularly important when it is pain induced by trauma of an operative wound. We have also seen how failure of ciliary action may offer additional obstruction to drainage from the bronchial tubes. During expiration, the bronchi decrease in both diameter and length, and, at the end of cough, the lumen of the bronchus may be so reduced that obstruction is momentarily complete. The ensuing inspiration, therefore, draws the obstructing mucus further into the periphery of the lung. The increasing bronchial diameter eventually breaks the barrier and re-establishes a passage for the incoming air. If the obstructing membrane fails to be broken during inspiration, the air distal to it is gradually misplaced or resorbed, and atelectasis or "drowned lung," or a combination of the two, must result.

Unlike other paired organs of the body, the lungs do not always render reciprocal aid to each other in times of need. This is due to the fact that evacuation of the pulmonary content from both sides takes place through a common exit — the trachea. In the presence of any condition which inhibits or impairs the emptying of one lung through its bronchial exit, the total exchange of air in the opposite lung is increased.

During cough, therefore, the blasts of air from the two lungs are forced to compete with each other for the occupation of the trachea. The blast of air from the handicapped lung is quickly overcome by its more powerful fellow of the opposite side so that its effectiveness is considerably reduced, if not entirely abolished.

The existence of emphysematous bullae in the lungs may also have a serious effect upon cough. In these cases, a considerable part of the volume of the thorax may be occupied by bubbles of entrapped air producing a serious reduction in the vital capacity of the lungs and, consequently, in the volume of air available for the driving force of cough. In the presence of emphysema it is frequently possible to observe bronchoscopically an inward bulging of the soft posterior wall of the bronchial tube during expiration. This change is naturally increased by the increased intrapulmonary pressure associated with cough. In the majority of cases the resulting mechanical narrowing of the bronchial lumen offers a barrier to the drainage of the distal portion of the lung. In exceptional cases, however, it may be so marked as to produce a complete temporary obstruction and the effectiveness of cough is inhibited in direct proportion to the degree of obstruction produced.

Bronchial obstruction has in the past been associated, in the clinician's mind, with major intrabronchial changes, new growth, foreign body or inflammatory stricture or granuloma. The production of atelectasis in this way is well understood. It is apparent from the study above, however, that the same effect may be produced by many smaller and easily overlooked conditions if the proper combination of circumstances should supervene. Hence, a chronic, productive cough which had been disregarded for years assumes an entirely new importance in the presence of a fractured rib. The point of importance is that many of these minor changes of great potential consequence may easily be overlooked in a general physical examination. They are just as easily detected, however, if the mechanism of pulmonary drainage is understood and kept in mind when the examination is made. The importance of this knowledge to the abdominal or general surgeon is patent. It is certain that he will avoid many headaches and recrimi-

nations by a careful study of the mechanisms leading to one of the commonest of postoperative complications.

## SUMMARY AND CONCLUSIONS.

The physiology of cough is examined in relation to pulmonary drainage.

A revised concept of pulmonary drainage is presented in which cough is assigned its special rôle.

On the basis of this new physiological concept, accessory changes, many of them minor in nature, are shown to acquire new importance in the presence of an impaired drainage mechanism.

The importance is stressed —particularly to the abdominal surgeon — of a careful study of the mechanism of pulmonary drainage and the preoperative examination of all patients in the light of this knowledge.

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# THE "BLOCKED EAR" OF THE CAISSON WORKER.*†

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There are so many important phases of compressed air work which deeply concern the practicing otologist that I can in the time allotted me, only briefly consider one of them. Of prime importance to the injured, to his employer, to the board of arbitration for workers' disabilities and, because of the interest of the foregoing, to the otologist as well, is the evaluation of compensation over and above that allowed for the trauma itself. It is this aspect of this large field that I consider of interest for our short discussion this evening.

The "blocked ear" is an expression used by the caisson worker, or sandhog, as he is commonly called, to denote some disturbance to the drum, tympanic cavity, or both, which has resulted from a failure to equalize the intra- and extratympanic air pressure. This can occur during compression or decompression in contradistinction to the labyrinthine lesions of caisson's disease (the "bends"), which follow only upon decompression. The blocked ear in most instances is experienced by the worker while he is being compressed in the air lock. Perhaps the reason for this is to be found in the anatomy of the Eustachian tube; its tympanic orifice is the end of a rigid funnel, whereas the pharyngeal opening is resilient and so can be compressed easily by high air pressure in the nasopharynx.

Disregarding carelessness by the lock-tender or mechanical defects in the pressure controls, the most important predisposing cause of a blocked ear is some degree of "tubal occlusion." This designation is inclusive, in that it embraces all conditions which may produce temporary or permanent obstruction to the patency of the Eustachian tube. Let me say here that seasoned sandhogs are all sufferers from a chronic hypertrophy of the mucous membrane lining the upper respiratory tract. But of all these, the common cold

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is the chief predisposing factor. This is borne out by the fact that the majority of blocked ears occur in workers who either disregard the specific instructions given them to abstain from going into air when they have a cold, or in those who feel that they have recovered from a coryza and report for work without medical advice from the physician assigned to the job.

Under normal conditions the sandhog, upon being locked in, is able at all times to equalize the pressure of the air in the middle ear with the changing pressure in the air lock. He is taught to do this by learning how to inflate his middle ears — he calls it "blowing" — and by swallowing repeatedly while he is in the lock. Where, however, a tubal obstruction is present, the ability to auto-inflate is lost, and unless the lock-tender is immediately notified that someone in the lock cannot "clear" his ears, so that he can ease up on the pressure valve, a blocked ear will have occurred in the worker.

The immediate symptom is severe, stabbing pain in the affected ear and a sensation of extreme fulness. Speech is heard without difficulty but sounds hollow and muffled. Otoscopic examination enables one to classify cases of blocked ear according to the severity of the lesion into first degree and second degree — the latter being further subdivided into mild, moderate and severe. The adoption of the designation "blocked ear" to describe this type of trauma is advisable because it, in itself, clarifies for all concerned with such an injury the exact cause, the possible pathological pictures to be expected and the sequellae to be looked for by the otologist in the light of compensability. The term "blocked ear" sets the lesion apart from others which may present a like clinical and otoscopic picture.

*Blocked Ear — First Degree:* There is noted here a marked retraction of the drum and a hyperemia of its blood vessels. The appearance differs from that of an acute catarrhal otitis media in that here the redness is not diffuse but is spotty and streaked, following the course of the vessels. Under magnification the arterioles can be seen radiating from the long process of the malleus toward the periphery anteriorly, superiorly and posteriorly, while the lower half of the pars tensa approximates the normal color of the drum. Another difference between the blocked ear, regardless of its severity, and

an acute catarrhal otitis media is that the otalgia disappears quickly, whereas in an O.M.C.A. intermittent pain persists for several days.

*Blocked Ear — Second Degree: Mild Form:* One or more hemorrhages are found in the tympanic membrane, and when seen shortly after the trauma they appear as purplish spots. Where the hemorrhage is solitary, it is most apt to be present in the posterosuperior quadrant. Next in frequency are the anterosuperior and posteroinferior quadrants. These are sharply outlined, nondissecting and, where multiple, noncoalescing and so do not increase beyond their original size. They do not form bullae and, therefore, can never be confused with the hemorrhagic blebs of a grippe otitis.

*Moderate Form:* Here will be found an intratympanic hemorrhage, with or without hemorrhage into the drum itself. Contrary to what one would expect, the membrana tympani is retracted and the bony landmarks accentuated, and it presents a diffuse purplish color. Upon magnification, the glistening white epidermal layer can be easily identified and the purple of the intratympanic hemorrhage can be seen shining through. Strange as it may seem, there is no difference in the symptoms complained of by those who have suffered a first degree blocked ear and by these two types of second degree blocked ear.

*Severe Form:* In the event of marked retraction, it is possible to visualize the incudostapedial articulation. The pressure of this joint against the membrane may result in a perforation. Lange attributes to this the frequency of hemorrhages in the posterosuperior quadrant. Even under magnification, it is often difficult to determine whether the tympanic membrane has been torn through completely, since the edges of small rents approximate quickly or are covered with a blood clot. Brüggeman noted that of the individual layers of the drum, the epidermal layer was torn more frequently than the other two.

Perforations may occur anywhere, and they may be of any size and number. The posterosuperior quadrant is affected most often, followed next by the area anterior to the umbo. When seen early, they present ragged margins and are central in type. Free bleeding may or may not accompany this type of blocked ear, and the intact portions of the drum may

or may not show isolated hemorrhagic spots. This, for the otologist, is an extremely important point because on several occasions I have heard testimony to the effect that bleeding from the ear is *prima facia* evidence of an injury to the internal ear. It has been my experience that a perforated drum in a blocked ear is most apt to occur in a tympanum which is the seat of scars or atrophic changes — and that this in itself might indicate a prior insult to hearing acuity.

*Hearing Loss Following Blocked Ear:* Seventy-four cases of blocked ear have come to my attention. The hearing loss can be considered, from the standpoint of compensation, in 46 of them. Twelve volunteered impaired hearing prior to the trauma; seven were seen after at least one week had elapsed following injury; six refused to have their hearing tested, and three were unquestionable malingerers. The remaining 46 all showed some immediate impairment in hearing. This acute loss shows no characteristic which might be interpreted as typical for this type of injury, either upon audiometric test with the Western Electric 2A and 6A or with the tuning forks. In 19, the immediate hearing loss was in the 2,048, 4,096 and 8,192 octaves. In 21, the drop was in the 128, 256 and 512 ranges. In the remaining three, wherein there was a bilateral blocked ear one showed a parallel loss for air conduction in the three upper notes, and in the other two there was a loss in one ear for the lower tones and in the other for the higher octaves.

In the vast majority of cases of blocked ear wherein no perforation has occurred, it has been my experience that the hearing returns to within normal limits after measures have been instituted to re-establish the patency of the Eustachian tube; and heat, in the form of diathermy, has aided in hastening the absorption of the hemorrhages. The average time for accomplishing this has been 16 days — four days being the shortest period and 28 days the longest. The severity of the blocked ear apparently has nothing to do with the length of time required for the hearing to return to approximately normal, since the longest period in my experience was in a mild case of first degree blocked ear.

Where a perforation of the drum has occurred, the hearing loss found upon examination is also difficult to classify from the industrial viewpoint. In two of these, the initial loss was

surprisingly little and affected only the upper tone range (from 1,024 to 8,192 d.v.), the maximum for any one note being 30 dcb. This observation coincides with that of the late Dr. Vail, who reported a case of blocked ear presenting two perforations with active hemorrhage from the middle ear.

*Evaluation of Disability:* In this type of industrial trauma, the otologist is in a peculiar position when called upon for his expert opinion. Of prime importance in my experience is not the injury itself but the length of time a man has been working in compressed air. They are well paid, far above the average, and the old hands take the ordinary blocked ear in their stride. Their sole interest when they are compelled by the doctor in the medical shack to go to an otologist is to get what they call the "passage" to the ear cleared as quickly as possible so that they can return to work. Many of them use commercial nose drops containing one or another mucosal constrictant to assure the patency of the tubes before going into air. When once the otologist has opened the tubes, they rarely report for further treatment, even though drum and middle ear changes still exist.

Because of this, few of us are in a position to evaluate the effect of compressed air work on the hearing of those steadily employed in this work. Such a survey in this country is virtually impossible by company doctors because such an attempt at accurate testing prior to employment might be interpreted by union officials as a subterfuge for discrimination in the hiring of labor. The need for this, however, is imperative and was obvious to Vail, who, in 1929, indicated that "a wide and careful survey must be made to decide whether the percentage of deafness is uniformly high in persons working under compressed air."

As I have indicated, there is no definite characteristic of a hearing loss due to a blocked ear. Nor, because of existing conditions in the industry, is it possible to obtain an estimation of hearing acuity, beyond the crudest types of tests, prior to employment, so that all concerned in the evaluation of disability might have a permanent record against which there can be compared a possible future insult to hearing following an episode of blocked ear. And, finally, we must bear in mind that there are various makes of audiometers in use, and that even two machines from the same manufac-

turer may give different curves in the same patient tested by the same person under the same conditions on the same day. Where, as frequently occurs in a contested case, the expert opinion of two otologists is presented to the court, the latter, for its own information, directs an examination by what it alludes to as an "impartial" examiner. Invariably, the hearing tests taken by all three are months apart from one another, often taken on three different machines under different conditions for soundproofing. The court obviously has not the time to concern itself with these minutiae, but from the standpoint of the injured, employer and carrier they mean dollars and cents.

In the blocked ear, there rarely arises the quesion of complete hearing loss in altercaticns for compensation. Here, we otologists are called upon to determine the degree of partial hearing loss following this injury, and since the decision of the New York State Court of Appeals in the case of Bednar vs. Ingersoll-Rand Co., where in effect it was decided that *even though no loss of earning power results from the hearing loss sustained,* partial compensation, *according to the percentage of loss found,* is rightly due to the injured. The decibel loss is not considered in this decision, nor are the differences which we otologists know exist in the various kinds of audiometers taken into consideration by the referee.

At the present and up until now, I have taken the stand that only that worker who, upon several tests at varying intervals up to at least six months, shows a closely identical audiometric loss on the *same* machine, or a similar persistent curve of hearing loss on a like machine from the same manufacturer is the only one whose compensation can be computed on a percentage basis, even though in principle this is wrong. Therefore, I submit:

*1.* That the clinical picture of the blocked ear is an entity.

*2.* That the increase in air travel will add to this problem.

*3.* That the effect of compressed air work upon hearing needs intensive study and that labor organizations be made aware of this problem.

*4.* That the estimation of compensability on the basis of percentage of hearing loss due to a blocked ear is as yet not

possible; and that the courts unwittingly are making us use our pending experimental investigations to serve their practical need for the dole of awards.

*5.* That in the interim, a disinterested board of examiners for hearing estimation be established, to which all cases of blocked ear will be referred, wherewith all elements of controversial nature will be reduced to a minimum.

*6.* That the otological profession establish quickly a standard of compensability for a loss in hearing due to the trauma of a blocked ear. I suggest further that this should be extended so as to embrace eventually all losses of hearing function due to injury.

*7.* That we otologists under the present setup think twice before we contradict one another on a given case. Let us remember when we're called for expert testimony that many factors other than our own opinion and observations enter into the final disposition of a case. Courts are not concerned with the medical aspects of a case beyond their desire to determine cause and effect, prognosis as to permanency of the injury and the estimation of damage from the monetary angle. Here, I submit that a blocked ear *per se* in the rarest of instances causes a permanent, debilitating and, in my opinion, compensable loss in hearing.

*8.* That I reiterate Vail's demand for a survey of hearing in compressed air workers. I go further in advocating legislative measures which will compel these artisans to have an accurate estimation of their hearing made before employment, so that what we otologists are vitally combating, namely, the increase in the number of the deafened, will be materially furthered.

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## BOOK REVIEW.

**Diseases of the Nose, Throat and Ear. By I. Simson Hall., M.B., Ch.B., F.R.C.P.E., F.R.C.S.E.; Surgeon to the Royal Infirmary, Edinburgh; Lecturer in Diseases of the Nose, Throat and Ear, University of Edinburgh. Second Edition with 446 pages including index, 74 illustrations in black and white, and four colored plates. Edinburgh: E. and S. Livingston, 16 and 17 Teviot Place. 1941. Price 15 s. net; postage 7 d.**

Periodically there appear, most often from English pens, small, condensed textbooks of otolaryngology, intended, according to the preface, for the general practitioner. The expressed objective is to conserve the reader's time, to afford him instruction in rapid diagnosis and to place within ready reach effective methods of treatment. The present book, already in a second edition, is such a miniature, modeled, as are most of its kind, after the well established text by Turner.

There is doubtless much merit in such books and the present one is pleasing in appearance. Somehow, to this reviewer the author, in spite of his prefatory explanation, seems unable to resist the temptation to include surgical procedures which cannot possibly concern the general practitioner and to omit adequate details in methods of examination without which none but a trained laryngologist could possibly secure needed information. Surely, photographs of the armamentarium for mastoidectomy and diagrams of the anatomy of the cochlea will be of little service to the busy man in general practice. Inclusion of clinical rarities and particularly of such technicalities as bronchoscopy further support this point of view. In this book the frequent use of out-of-date photographs is not in keeping with the most up-to-date ideas of medical illustration.

The author has made an earnest attempt to provide for the triple needs of the student, the specialist and the general practitioner. Since, however, each group ideally requires a different type of book, mere reduction in size, with simultaneous inclusion of material desirable for all groups, does not necessarily fill the needs of the general practitioner. Properly, he, too, should have a book designed particularly for his special requirements. L. G. R.